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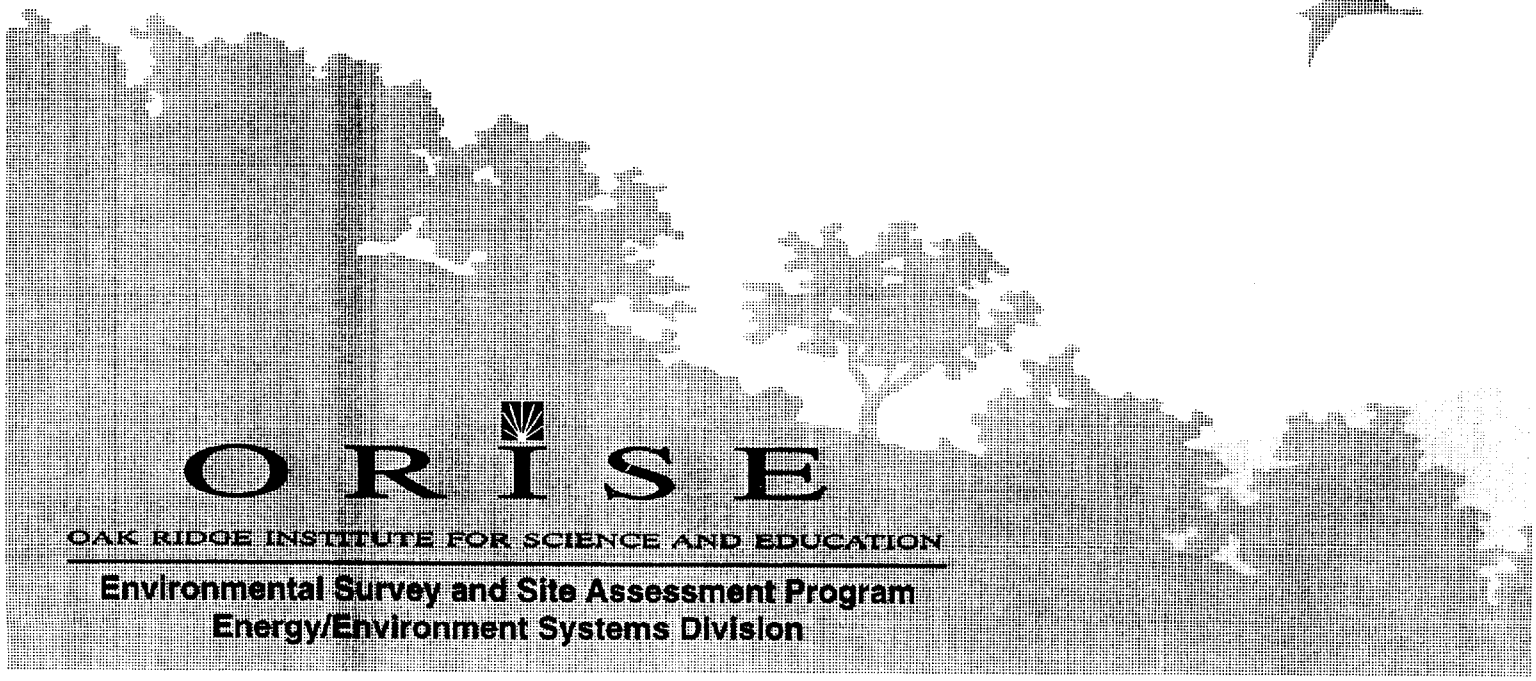
DESIGNATION SURVEY ADDENDUM REPORT COMBUSTION ENGINEERING SITE WINDSOR, CONNECTICUT

E. W. ABELQUIST

Prepared for the Office of Environmental Restoration
U.S. Department of Energy



ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

DESIGNATION SURVEY
ADDENDUM REPORT
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Prepared by

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Prepared for the

Office of Environmental Restoration
U.S. Department of Energy

FINAL REPORT

JULY 1996

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NOTICES

DESIGNATION SURVEY
ADDENDUM REPORT
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
cm	centimeter
CE	Combustion Engineering
cm^2	square centimeter
cpm	counts per minute
DOE	U.S. Department of Energy
DOE-EM	Office of Environmental Restoration and Waste Management
DOE-ORO	DOE Oak Ridge Operations
ESSAP	Environmental Survey and Site Assessment Program
EU	enriched uranium
FSRD	Former Sites Restoration Division
ft^2	square feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
h	hour
ha	hectare
HEU	highly enriched uranium
KAPL	Knolls Atomic Power Laboratory
kg	kilogram
km	kilometer
m	meter
m^2	square meter
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
pCi/g	picocuries per gram

DESIGNATION SURVEY
ADDENDUM REPORT
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

INTRODUCTION AND SITE HISTORY

Combustion Engineering (CE) has operated a facility in Windsor, Connecticut as part of its efforts as a contractor for the Atomic Energy Commission (AEC), predecessor agency of the Department of Energy (DOE), on nuclear reactor and fuel projects. Beginning in 1955 and continuing for over a decade, CE served as a direct contractor to the AEC and as a subcontractor to other firms for a number of projects involving the use of highly enriched uranium (HEU) provided by the AEC. The uranium furnished for use at the CE facility varied from about 5% to over 90% enrichment of U-235 (USDOE 1993).

In the late 1950's, CE constructed a Naval reactor prototype under contract with the AEC on a portion of CE property. The CE site was later subdivided, with the 4-hectare (ha) Naval reactor prototype site becoming a U.S. government property. CE retained ownership of the remainder of the property. The Naval reactor prototype is now shutdown and defueled and is maintained by Knolls Atomic Power Laboratory (KAPL) under contract with the Department of Energy Office of Naval Reactors. CE also currently operates a nuclear fuel manufacturing facility licensed by the Nuclear Regulatory Commission (NRC), number SNM-1067, on the Windsor site.

The portions of the Windsor site formerly used for the AEC included Buildings 3, 5 and 6, the related drainpipes and sewer lines, the waste storage pad area, and the drum burial site. Specifically, DOE's authority at the CE site is limited only to the following: (1) Building 3; (2) other facilities or areas associated exclusively with Building 3 (i.e., sewer lines); or (3) contamination that is exclusively high-enriched uranium (i.e., enriched to more than 20 percent in the isotope uranium-235). In addition, DOE has authority to address Co-60 or other radionuclides in the Site Brook as a result of the operations of the Naval reactor prototype.

The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute of Science and Education (ORISE) performed a designation survey at the Combustion Engineering site in November 1993 (ORISE 1994). The interior designation survey activities consisted of alpha, beta and gamma scans of the floors, walls, drains and equipment, measurements of total and removable activity, and miscellaneous sampling. The exterior survey activities consisted of gamma scans of the outdoor areas, and soil and miscellaneous sampling.

Results of the designation survey identified several interior and exterior locations as containing highly enriched uranium (greater than 20% enrichment in the U-235 isotope)—including a floor drain location, pipe insulation wrap in the Drop Tube Furnace Testing area, and the north wall and Vault Room within Building 3. The exterior areas include the waste storage pad area, drum burial pit, grounds north of Building 3, Site Brook bank, sewer and industrial lines, and the Site Brook (ORISE 1994).

The Department of Energy's (DOE) Office of Environmental Restoration and Waste Management (EM) requested that the current radiological condition of the CE site be re-evaluated, based on an additional review of the existing data and in preparation of characterization survey planning. Additional activities subsequent to the publication of the designation survey report have included a technical report on the distribution coefficients of uranium and Co-60 (ANL 1996) and the analysis of over 120 sediment samples collected from the Site Brook by KAPL in 1991. These 120 samples were taken to increase KAPL's information on the quantity and distribution of radioactivity in the Site Brook originating from the Naval reactor prototype. This report discusses the updated radiological condition for the CE site, and provides summarized information to assist in the planning for further characterization activities at the CE site.

SITE DESCRIPTION

The CE site, covering approximately 445 hectares (1100 acres), is located on Day Hill Road in a mixed industrial and residential area approximately 5 kilometers southwest of Bradley International Airport (Figure 1). Interstate 91 runs to the east of the site and the Site Brook runs east to west on the north end of the site and joins the Farmington River northwest of the site. The site is comprised

of more than a dozen buildings with several smaller support facilities (Figure 2). The site is also characterized by various wooded areas and three ponds.

The waste storage pad area is an approximately 110 m x 220 m plot of land, lightly wooded with a mildly sloping terrain, located at the interior of the site. The drum burial pit, approximately five times smaller in area than the waste storage pad area, is characterized by level terrain situated between two steep embankments.

Uranium fuel fabrication was historically performed in Buildings 3, while Building 5 was similarly used for AEC contract work. Buildings 3 and 5 are currently used to support research and development projects. Building 6 served as a waste dilution and pumping facility for the liquid streams from Buildings 3 and 5. Two sewer lines discharged material from Building 6, one to the sewage treatment facility and the other to the Site Brook.

OBJECTIVE

The objective of this re-evaluation was to provide updated information on the radiological conditions of the CE site—relative to uranium with an enrichment of not less than 20% in the U-235 isotope. Additionally, radionuclide analyses of over 120 sediment samples from the Site Brook—collected in 1991 by KAPL—provided a data set to further characterize the uranium contamination in the Site Brook. The results of this revised data will be used by DOE/EM and DOE contractors to provide a basis for further characterization of the CE site, where further actions under FUSRAP may be warranted.

DOCUMENT REVIEW

ESSAP reviewed the site background information provided by the DOE (USDOE 1993), and the technical report provided by ANL (ANL 1996).

PROCEDURES

During the period from November 15 through 18, 1993, ESSAP performed a designation survey of the Combustion Engineering Site. The survey was in accordance with a survey plan dated November 12, 1993 submitted to and approved by the DOE (ORISE 1993). ORISE prepared a designation survey report that provided the survey procedures and results of this survey (ORISE 1994). On May 10, 1996, ESSAP received 121 sediment samples from the Site Brook which had been collected by KAPL personnel in 1991. This report summarizes the results of the designation survey, analytical results of sediment samples collected from the Site Brook by KAPL in 1991, and sample results obtained by ANL. A coding scheme using colors and symbols was developed to graphically present the sample results according to total uranium concentration and % U-235 enrichment:

Total Uranium Concentration	% U-235 Enrichment
< 50 pCi/g - green	< 8% - octagon (○)
> 50 and < 100 pCi/g - blue	> 8 and < 15% - triangle (△)
> 100 pCi/g - red	> 15 and < 20% - square (□)
	≥ 20% - diamond (◇)

This coding scheme may be used to quickly identify those building locations and exterior areas that DOE has authority to remediate under FUSRAP.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to the ESSAP Oak Ridge laboratory for analyses and interpretation. Ninety-five (95) soil and miscellaneous samples from the 1993 designation survey, as well as the 121 additional KAPL sediment samples, were dried and then analyzed by gamma spectrometry. Spectra were reviewed for U-235 and U-238, and any other identifiable photopeaks. Three of the KAPL sediment samples were also analyzed for Ni-63. Thirty-six (36) of the samples from the 1993 designation survey were also analyzed by alpha spectrometry, as were twenty-two (22) of the KAPL sediment samples. Samples were selected for alpha spectrometry analyses based on

the results of gamma spectrometry— to provide better estimates of the % EU and total uranium concentration. Soil and miscellaneous samples results were reported in units of picocuries per gram (pCi/g) dry weight. The percent U-235 enrichment was calculated by dividing the U-234, U-235, and U-238 activity concentrations by their respective specific activities, and determining the ratio of the U-235 isotopic weight to the total uranium weight. Specifically,

$$\%\ EU = \frac{U\text{-}235/2.14E6}{U\text{-}235/2.14E6 + U\text{-}238/3.33E5 + U\text{-}234/6.19E9},$$

where U-235, U-238, and U-234 are the activity concentrations in pCi/g, and the numerical values are the respective specific activities for each isotope. For samples that were only analyzed by gamma spectrometry, the U-234 was estimated based on an assumed U-234 to U-235 ratio of 24. This ratio was based on the analysis of 58 samples by alpha spectrometry. It should be noted that background subtraction on samples was not performed; which may affect the reported values for % EU and total uranium concentrations. Additional information concerning major instrumentation and analytical procedures is provided in Appendices A and B.

FINDINGS AND RESULTS

The analytical results for the following areas are presented in Tables 1 through 9. Tables 1 through 5 and 7 provide gamma spectrometry data, while Tables 6 and 8 provide isotopic uranium results from alpha spectrometry. Table 9 presents the analytical results reported by ANL (1996). The alpha and gamma spectrometry results are discussed consecutively for each site area.

INTERIOR

Uranium concentrations in miscellaneous samples (i.e., residue, fiberglass insulation, paint, etc.) collected from drains, sumps, walls and floors are presented in Tables 1 and 6. The total uranium concentrations in three Building 3 drain residue samples (drain #'s 2 through 4) were less than 47 pCi/g, with corresponding U-235 enrichments less than approximately 4% (Table 1). Alpha spectrometry analysis of drain residue sample #1 resulted in a total uranium concentration of 13,190 pCi/g and a U-235 enrichment of 44% (Table 6). Refer to Figure 3 for the graphical representation

of the % U-235 enrichment and total uranium concentration in Building 3 drains. The total uranium activity in the fiberglass sample from the Building 3 west wall location #3 was approximately 1,600 pCi (Table 1), with a corresponding U-235 enrichment of approximately 0.68%. The total uranium concentration in one sample of pipe insulation wrap in the Drop Tube Furnace Testing Area was 2,500 pCi/g, with a corresponding U-235 enrichment of approximately 20% (Table 1). Alpha spectrometry analyses, performed on 6 fiberglass samples from Building 3 east, south, and west walls (Figures 4, 5, and 6), resulted in total uranium concentrations ranging from 1.60 to 601.33 pCi/g, and corresponding U-235 enrichments ranging from 0.59% to 38% (Table 6).

Alpha spectrometry analysis on two paint samples from the Building 3 north wall and Vault Room wall (Figure 7) resulted in total uranium concentrations of 43.8 and 864 pCi/g, and corresponding U-235 enrichments of 46% and 32%, respectively (Table 6).

The total uranium concentration in an equipment residue sample in the basement of Building 6 was 11,000 pCi/g, with a corresponding U-235 enrichment of about 4% (Table 1). Alpha spectrometry analyses of floor residue and a sediment sample from the sump resulted in total uranium concentrations of 9,760 and 13,850 pCi/g, respectively, with a U-235 enrichments of 9.9 and 13% (Table 6). Refer to Figure 8.

EXTERIOR

Uranium Concentrations in Soils

Uranium concentrations in soil samples, collected both randomly and from locations of elevated direct radiation, are summarized in Tables 2, 3 and 6. The total uranium concentrations in the waste storage pad area ranged from <4.0 to 54,000 pCi/g (Table 2), and corresponding U-235 enrichments ranged from 0.80% to 86% (Table 2). Alpha spectrometry analysis, performed on 11 samples from the waste storage pad area (Figure 9), resulted in total uranium concentrations ranging from 21.02 to 2,430 pCi/g, and corresponding U-235 enrichments ranging from 23% to 65% (Table 6).

The total uranium concentrations in the drum burial pit (Figure 10) ranged from < 3.6 to 16,000 pCi/g (Table 3), and corresponding U-235 enrichments of 1.4 to 82% (Table 3). Alpha spectrometry analysis, performed on 3 samples from the drum burial pit, resulted in total uranium concentrations of 25.5, 345 and 917 pCi/g, and corresponding U-235 enrichments of 33%, 53% and 58% (Table 6).

The total uranium concentrations in grounds north of Building 3 (Figure 11) ranged from < 5.2 to 3,700 pCi/g, and U-235 enrichments of 0.57, 6.0, and 74 (Table 3). Alpha spectrometry analysis, performed on 3 samples from the grounds north of Building 3, resulted in total uranium concentrations of 39.1, 601 and 768 pCi/g, and corresponding U-235 enrichments of 3.7%, 39% and 36% (Table 6).

Alpha spectrometry analysis of the 3 sediment samples from the site brook bank (Figure 14) resulted in a total uranium concentrations of 418, 967, and 24,090 pCi/g, and corresponding U-235 enrichments of 27%, 86% and 17% (Table 6). Much of the uranium contamination on the site brook bank appeared to be associated with partially buried clam shells. Additional laboratory analysis was performed to evaluate the quantity of uranium activity separately for both the clam shell fraction and the soil fraction. The percentage of U-235 in the soil component ranged from 63% to 93%, and from 7% to 37% in the clam shell component.

The total uranium concentrations in the septic field (Figure 12) and sewage treatment facility grounds (Figure 13) ranged from < 3.8 to 40 pCi/g, with corresponding U-235 enrichments less than 1.9% (Table 3).

Uranium Concentrations in Miscellaneous Samples

Uranium concentrations in sediment samples collected from manhole access locations to sewer and industrial lines (Figure 15) are summarized in Tables 4 and 6. The total uranium concentrations in these samples ranged from < 3.1 to 97,000 pCi/g, % U-235 enrichments ranged from 0.61 to 74% (Table 4). Alpha spectrometry analysis, performed on 4 samples from the manhole access locations, resulted in total uranium concentrations ranging from 334 to 4,900 pCi/g, and corresponding U-235 enrichments ranging from 8.0% to 55% (Table 6).

The total uranium concentrations in residue samples collected from the Building 3 roof vents were <74 pCi/g (Table 1), with corresponding U-235 enrichments less than 2.4%.

The U-235 activity on the buried piece of plastic near the drum burial pit was 307,400 pCi (Table 1), with a corresponding U-235 enrichment of approximately 71%.

Uranium Concentrations in Site Brook Samples

Uranium concentrations in sediment samples collected by ORISE from the site brook (Figure 16) and outfall to the Small Pond are summarized in Tables 5 and 6. The total uranium concentrations in these samples ranged from <3.5 to 440 pCi/g, % U-235 enrichments ranged from 1.5 to 11.0% (Table 5). Alpha spectrometry analysis of the Site Brook location #8 sediment sample resulted in a total uranium concentration of 16,740 pCi/g and a U-235 enrichment of 58% (Table 6).

Uranium concentrations in sediment samples collected by KAPL from the Site Brook (Figures 17 through 19) are summarized in Tables 7 and 8. Uranium concentrations in excess of natural concentrations are detectable from the vicinity of the CE outfalls into the brook to the mouth of the brook in the Farmington River. The total uranium concentrations in these samples ranged from <0.4 to 1009 pCi/g (Table 7), with corresponding U-235 enrichments ranging from 0 to 66.12% (Table 7). Of the 121 sediment samples analyzed, only 5 samples exhibited U-235 enrichments greater than 20%. Alpha spectrometry analyses of 22 sediment samples from the Site Brook resulted in total uranium concentrations of 1.51 to 1080 pCi/g, and U-235 enrichments ranging from 0.89 to 48.16% (Table 8).

Cobalt-60 and Nickel-63 Concentrations in Site Brook Samples

Along with uranium present from CE operations, Co-60 has been detected in the Site Brook. This Co-60 is due to discharges of water prior to 1979 containing small amounts of residual radioactivity from a government-owned Naval reactor prototype. Ni-63 is commonly found in association with Co-60 from Naval reactors.

Co-60 concentrations in the 121 brook sediment samples provided by KAPL (Figures 17 through 19) ranged from <0.1 pCi/g to 46.9 pCi/g (Table 7). Ni-63 analysis was performed on the three sediment samples with the highest concentration of Co-60. The Ni-63 results were 26.7 ± 1.5 pCi/g, 13.2 ± 1.3 pCi/g and 7.2 ± 1.2 pCi/g, for samples S7, SC6, and S27, respectively.

Results of samples collected by ANL are shown in Table 9 (Figures 20 and 21). These results are consistent with those obtained by ORISE.

COMPARISON OF RESULTS WITH GUIDELINES

DOE is authorized to perform remediation at locations where the uranium contamination exceeds 20% U-235 enrichment and the total uranium concentration exceeds the residual surface contamination or soil guideline.

The site-specific soil guideline for enriched uranium will be determined pursuant to DOE Order 5400.5 (USDOE 1990).

Analyses of miscellaneous samples collected from interior areas identified the following locations within Building 3 as contaminated with EU: drain location #1 (Figure 3), east wall (Figure 5), pipe insulation wrap in the Drop Tube Furnace Testing Area (Figure 6), and the north wall and Vault Room (Figure 7). The sediment sample collected from the Building 6 sump, while containing significant quantities of uranium contamination, did not exceed the 20% U-235 enrichment action level.

Analyses of soil and sediment samples collected from outdoor areas identified the following locations as contaminated with EU: waste storage pad area (Figure 9), drum burial pit (Figure 10), grounds north of Building 3 (Figure 11), Site Brook bank (Figure 14), sewer and industrial lines at manhole access locations (Figure 15), and the Site Brook (Figures 16 through 18).

Designation survey activities did not identify EU contamination at any locations within Building 5, on the grounds of the septic field or sewage treatment facility, on any roof surfaces or vents, or the outfall to the Small Pond (ORISE 1994).

SUMMARY

At the request of the U.S. Department of Energy, the Oak Ridge Institute for Science and Education's Environmental Survey and Site Assessment Program re-evaluated the current radiological condition of the CE site, based on a review and summary of the available data. Additional activities subsequent to the publication of the designation survey report (ORISE 1994) have included a technical report on the distribution coefficients of uranium and Co-60 (ANL 1996) and the analysis of 121 sediment samples collected from the Site Brook by the Knolls Atomic Power Laboratory (KAPL) in 1991.

The Department of Energy is authorized to perform remediation at locations where the uranium contamination exceeds 20% U-235 enrichment and the total uranium concentration exceeds the residual surface contamination or soil guideline. The designation survey has identified several interior and exterior locations where these criteria appear to be satisfied. The interior areas include drain location #1, east wall location #2, pipe insulation wrap in the Drop Tube Furnace Testing area, and the north wall and Vault Room wall within Building 3. The exterior areas include the waste storage pad area, drum burial pit, grounds north of Building 3, Site Brook bank, sanitary sewer and industrial drain lines, and the Site Brook.

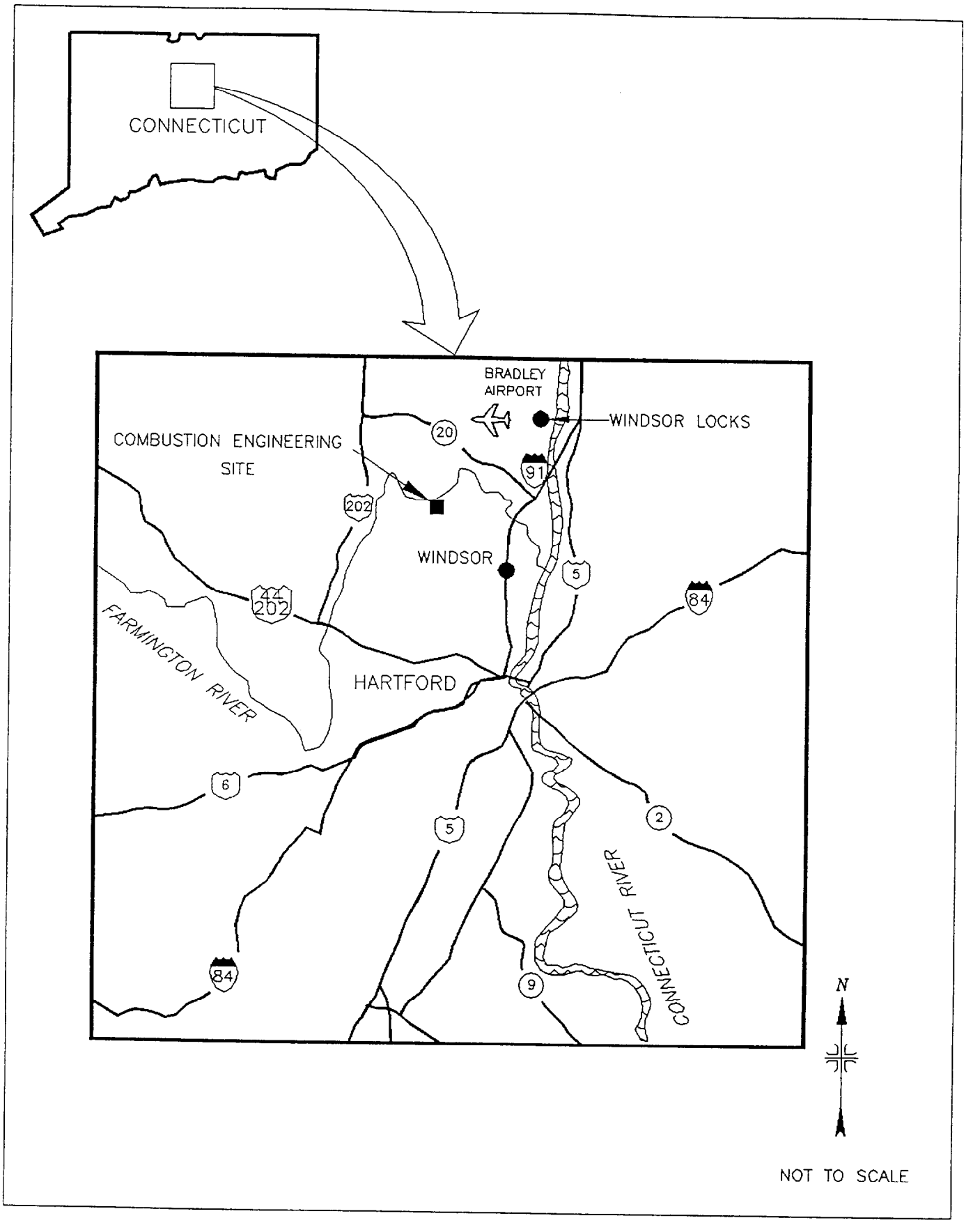


FIGURE 1: Location of the Combustion Engineering Site – Windsor, Connecticut

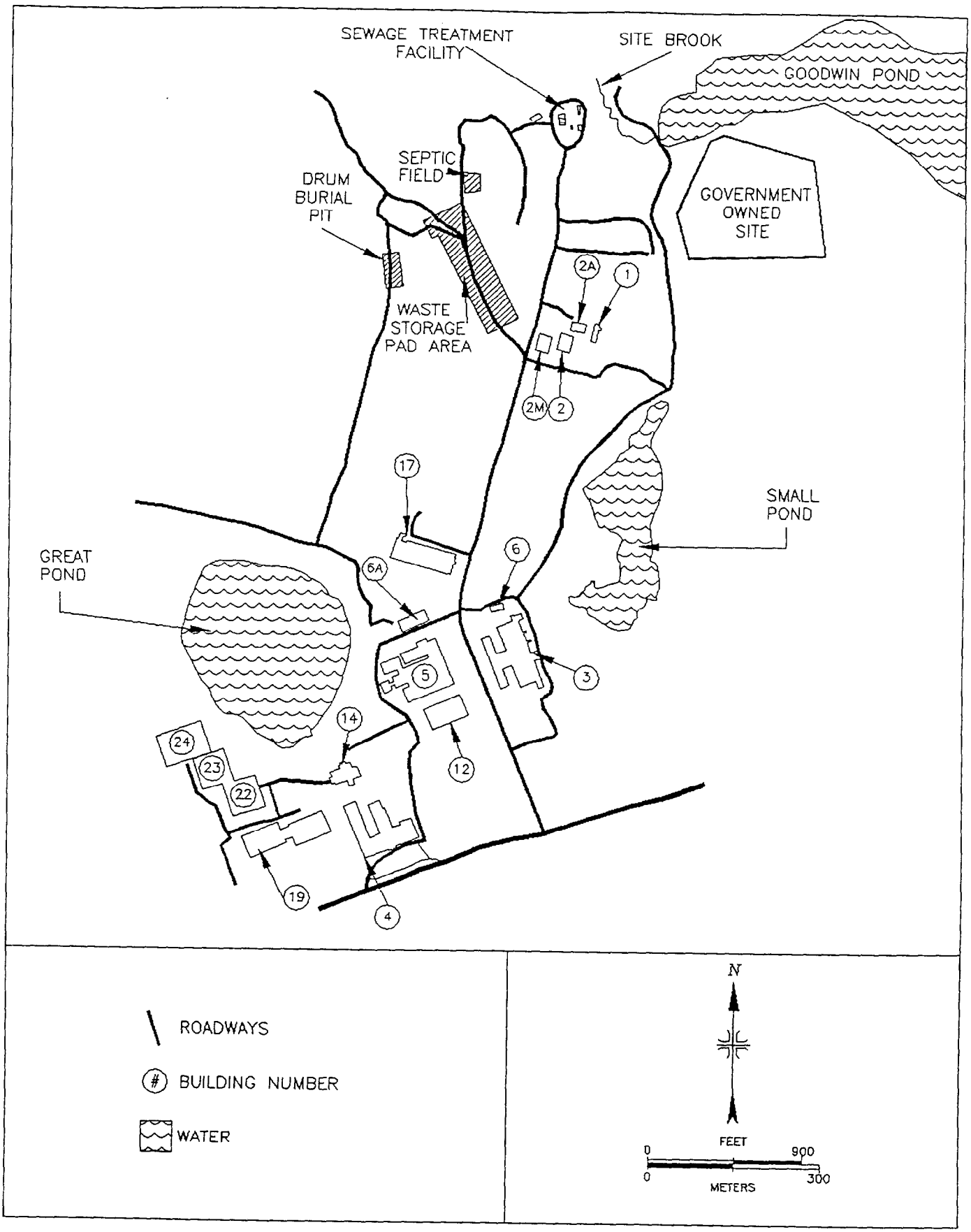


FIGURE 2: Plot Plan of the Combustion Engineering Site – Windsor, Connecticut

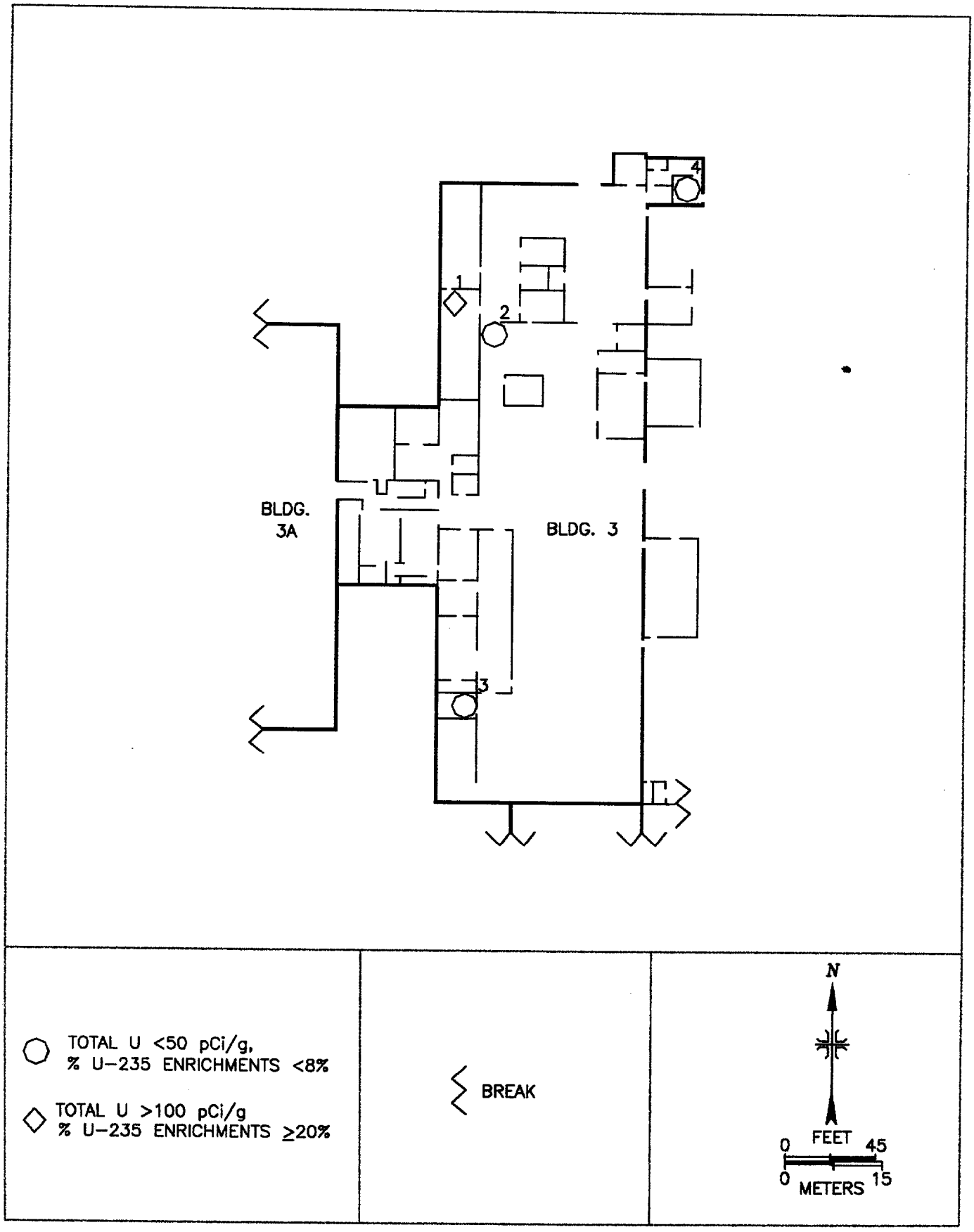


FIGURE 3: Building 3, Drains – Measurement and Sampling Locations

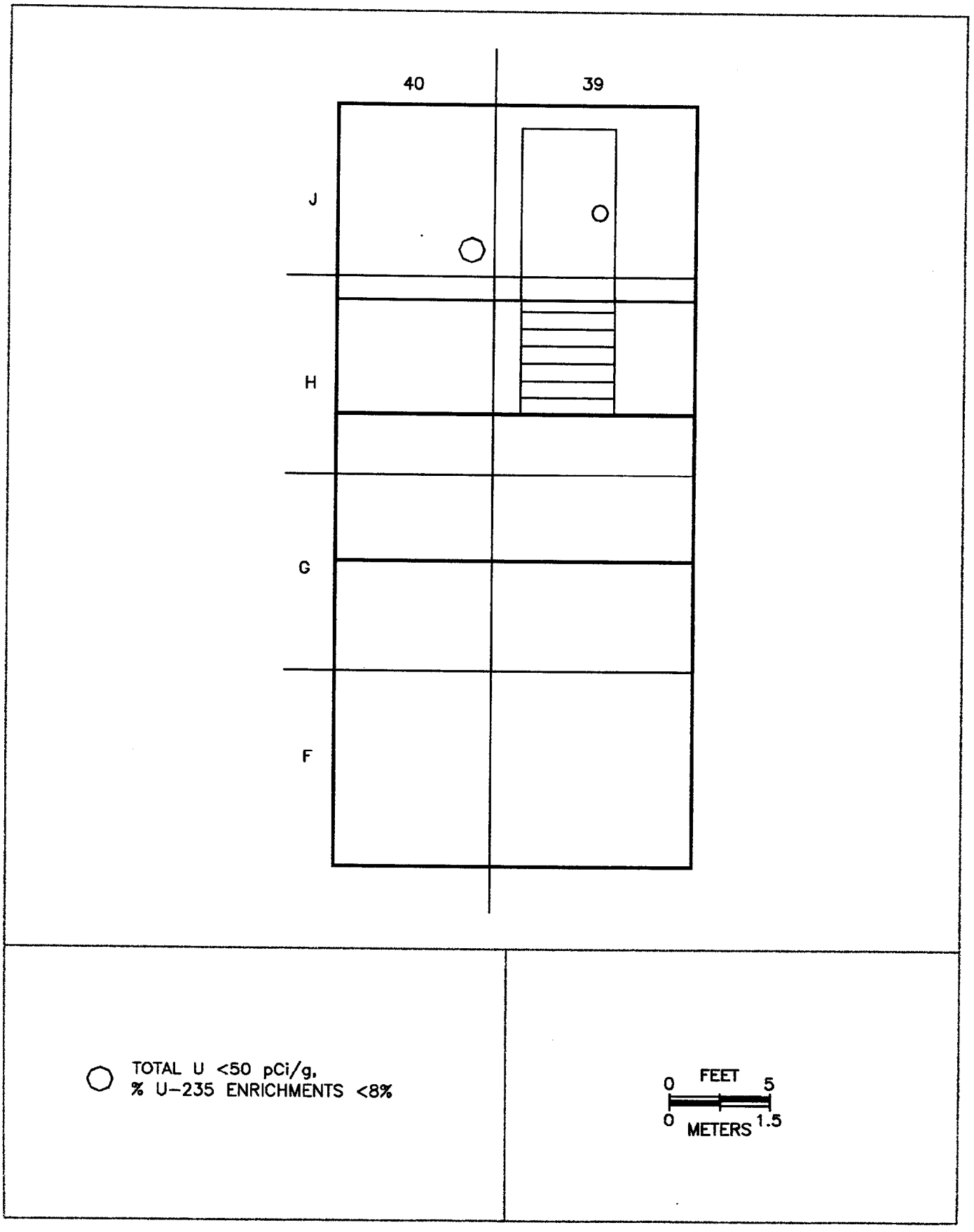
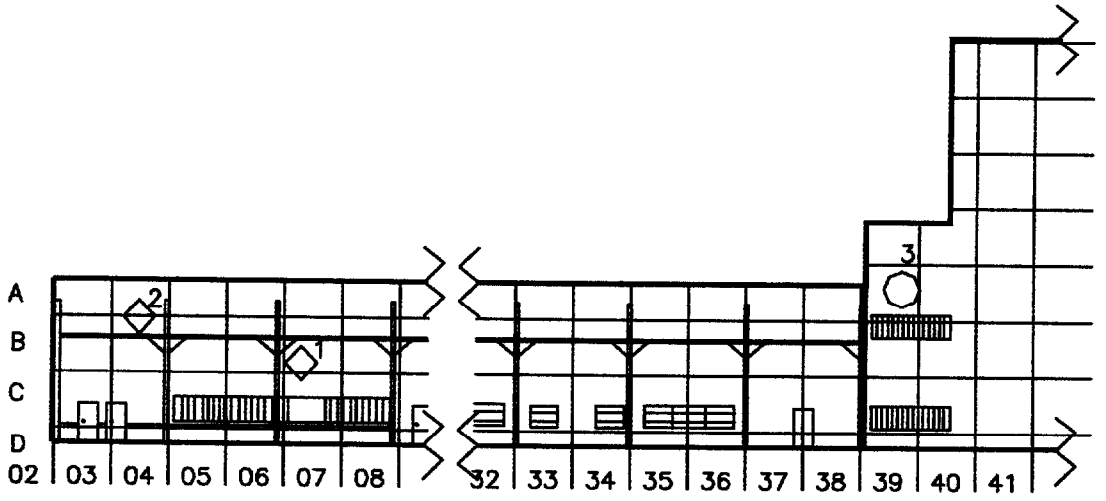


FIGURE 4: Building 3, High Bay, West Wall – Measurement and Sampling Locations



TOTAL U <50 pCi/g, % U-235 ENRICHMENTS <8%

TOTAL U EXCEEDING 50 pCi/g AND <100 pCi/g % U-235 ENRICHMENTS ≥20%

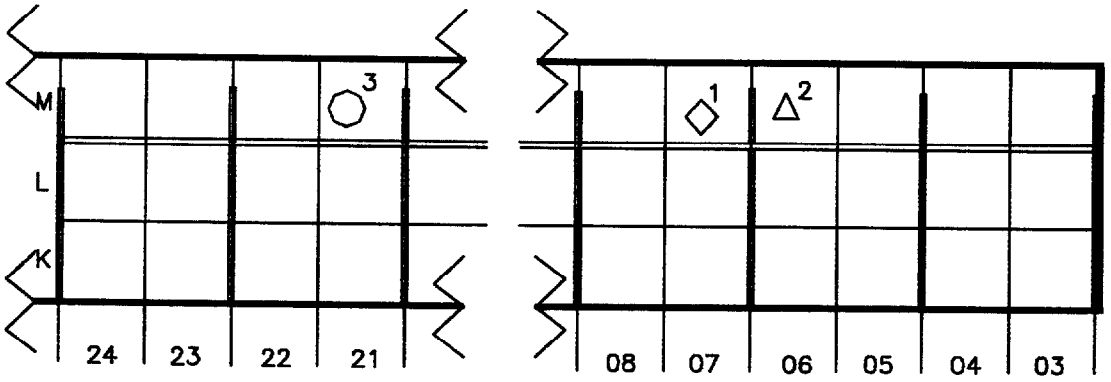
TOTAL U >100 pCi/g % U-235 ENRICHMENTS ≥20%

BREAK

FEET 0 30

METERS 0 10

FIGURE 5: Building 3, East Wall – Measurement and Sampling Locations



△ TOTAL U <50 pCi/g, % U-235 ENRICHMENTS BETWEEN 8 AND 15%

○ TOTAL U >100 pCi/g, % U-235 ENRICHMENTS <8%

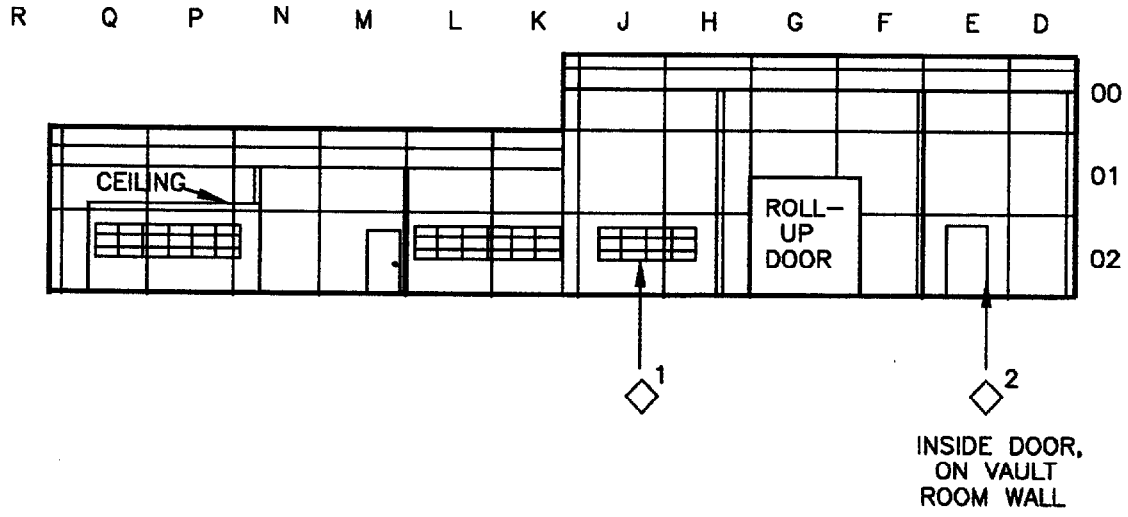
◇ TOTAL U >100 pCi/g % U-235 ENRICHMENTS ≥20%

BREAK

FEET 0 30

METERS 0 10

FIGURE 6: Building 3, West Wall Above Crane Rail – Measurement and Sampling Locations



◇ TOTAL U <50 pCi/g
% U-235 ENRICHMENTS ≥20%

◇ TOTAL U >100 pCi/g
% U-235 ENRICHMENTS ≥20%

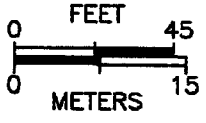


FIGURE 7: Building 3, North Wall – Measurement and Sampling Locations

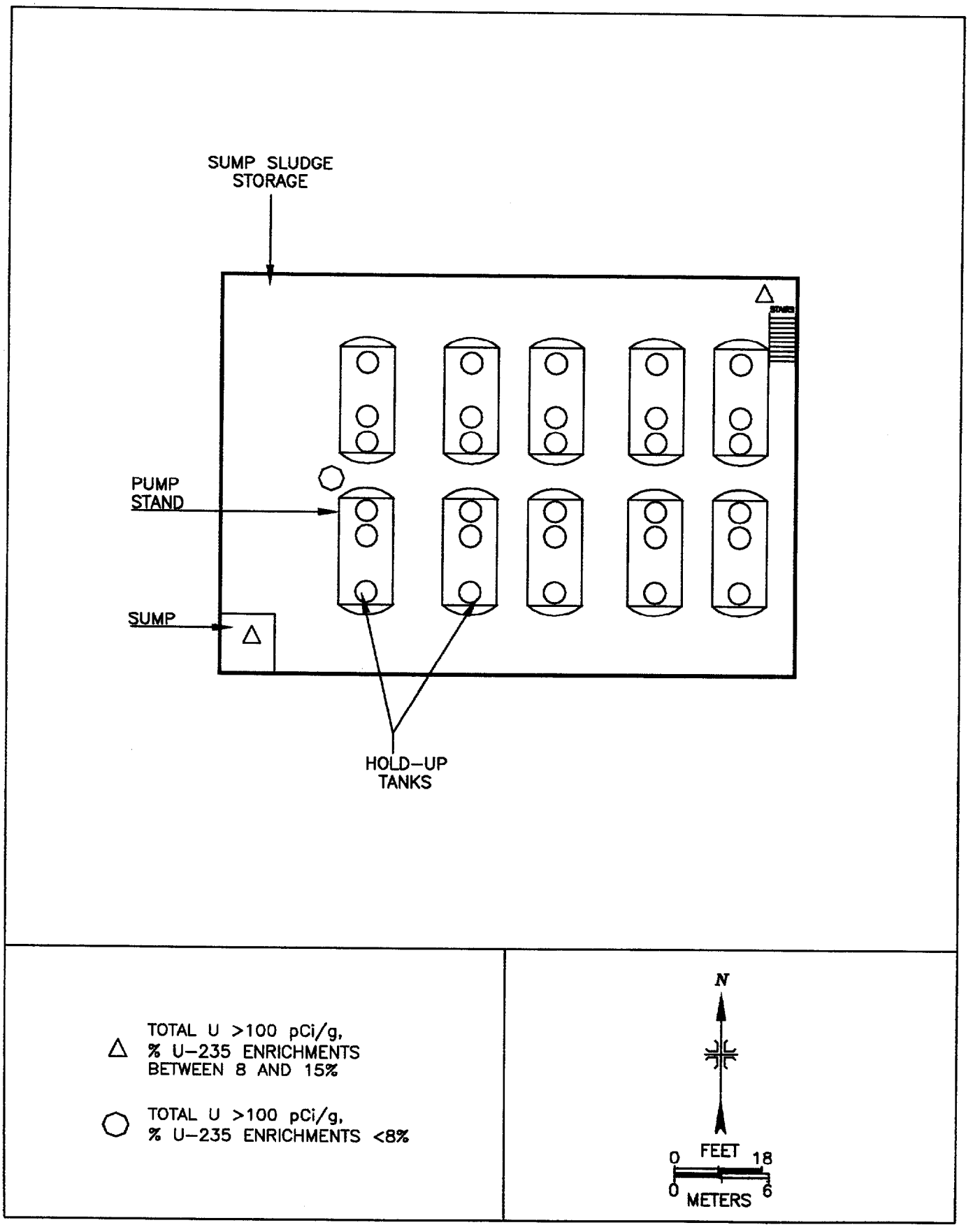


FIGURE 8: Building 6, Basement – Measurement and Sampling Locations

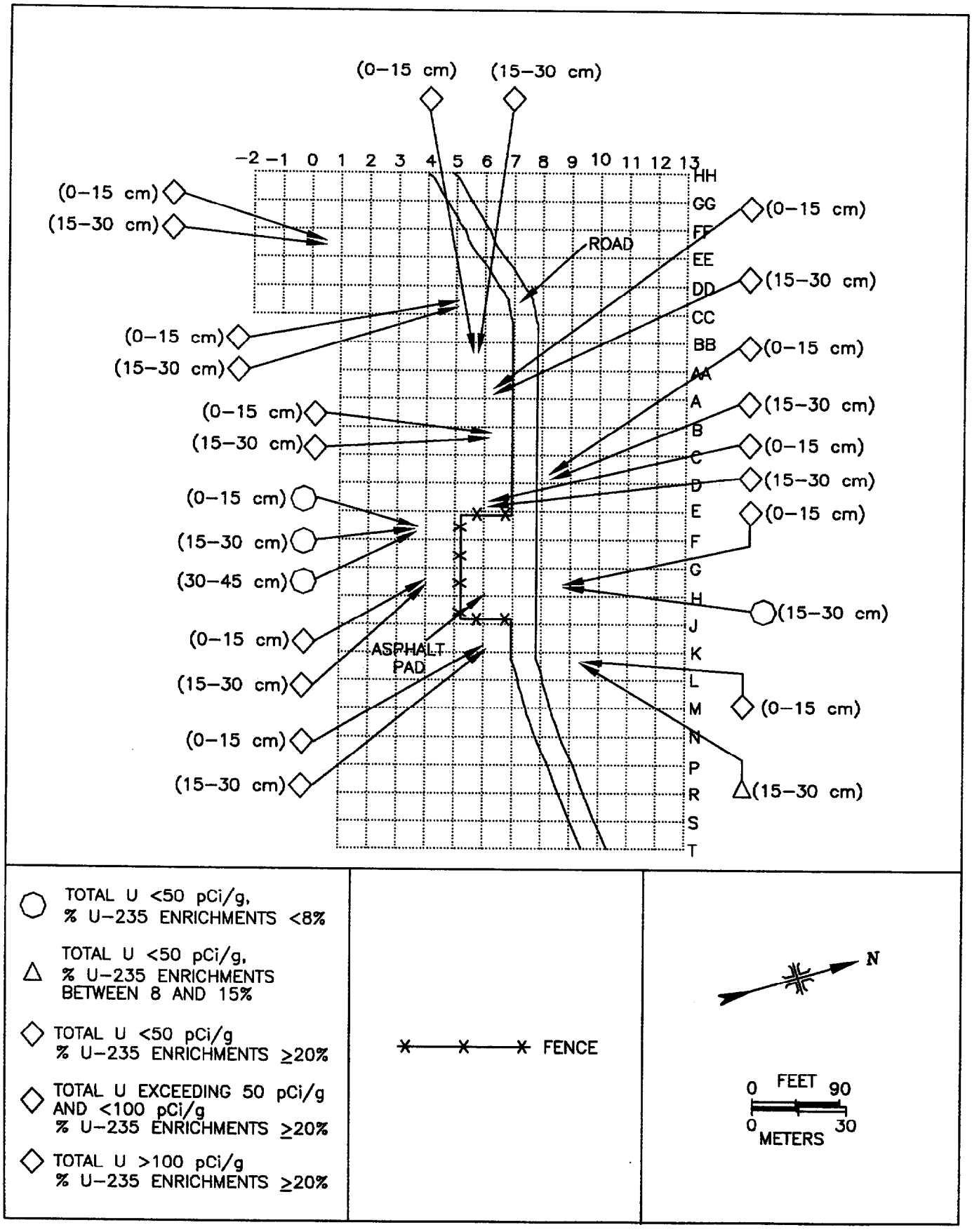


FIGURE 9: Waste Storage Pad Area – Measurement and Sampling Locations

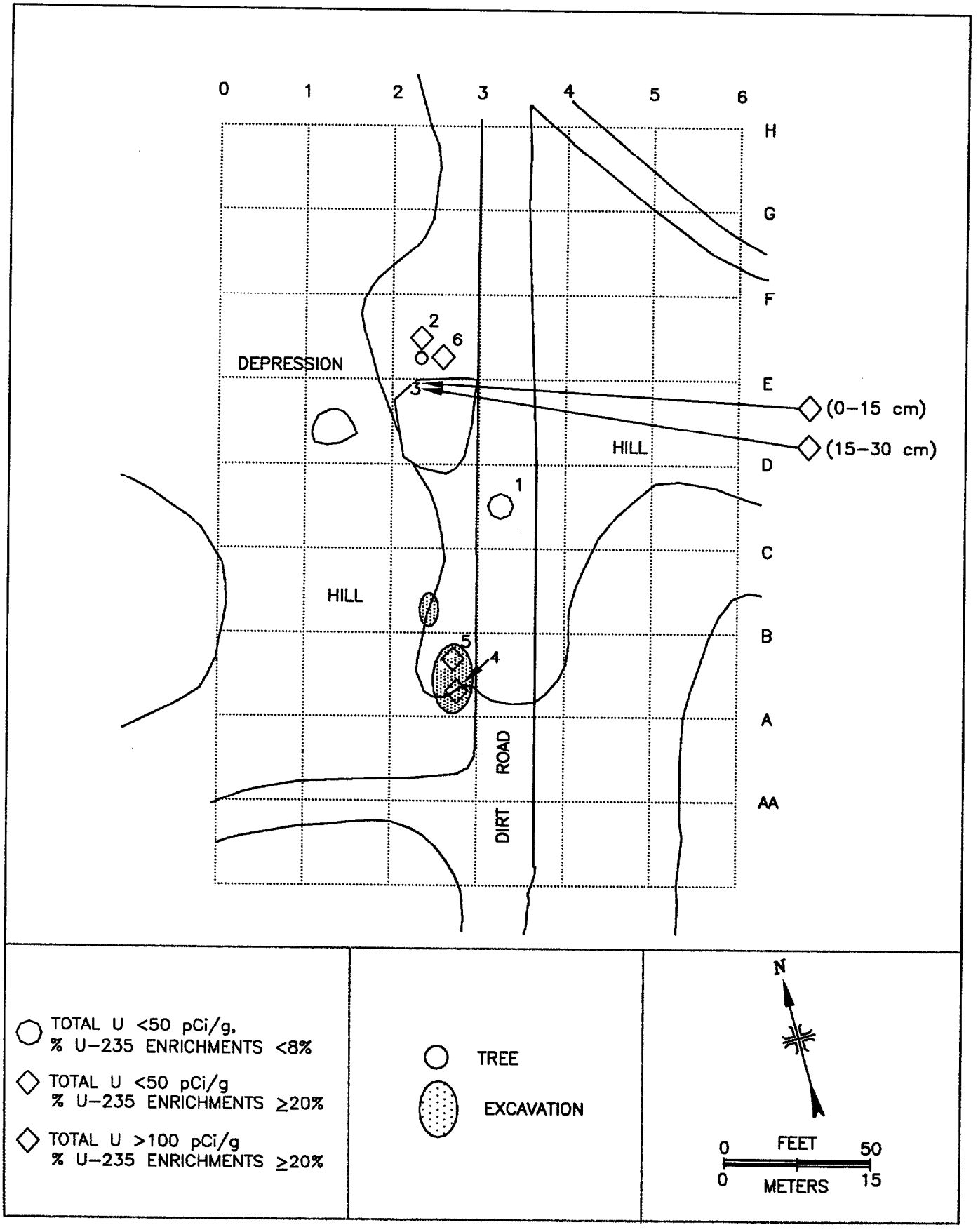


FIGURE 10: Drum Burial Pit – Measurement and Sampling Locations

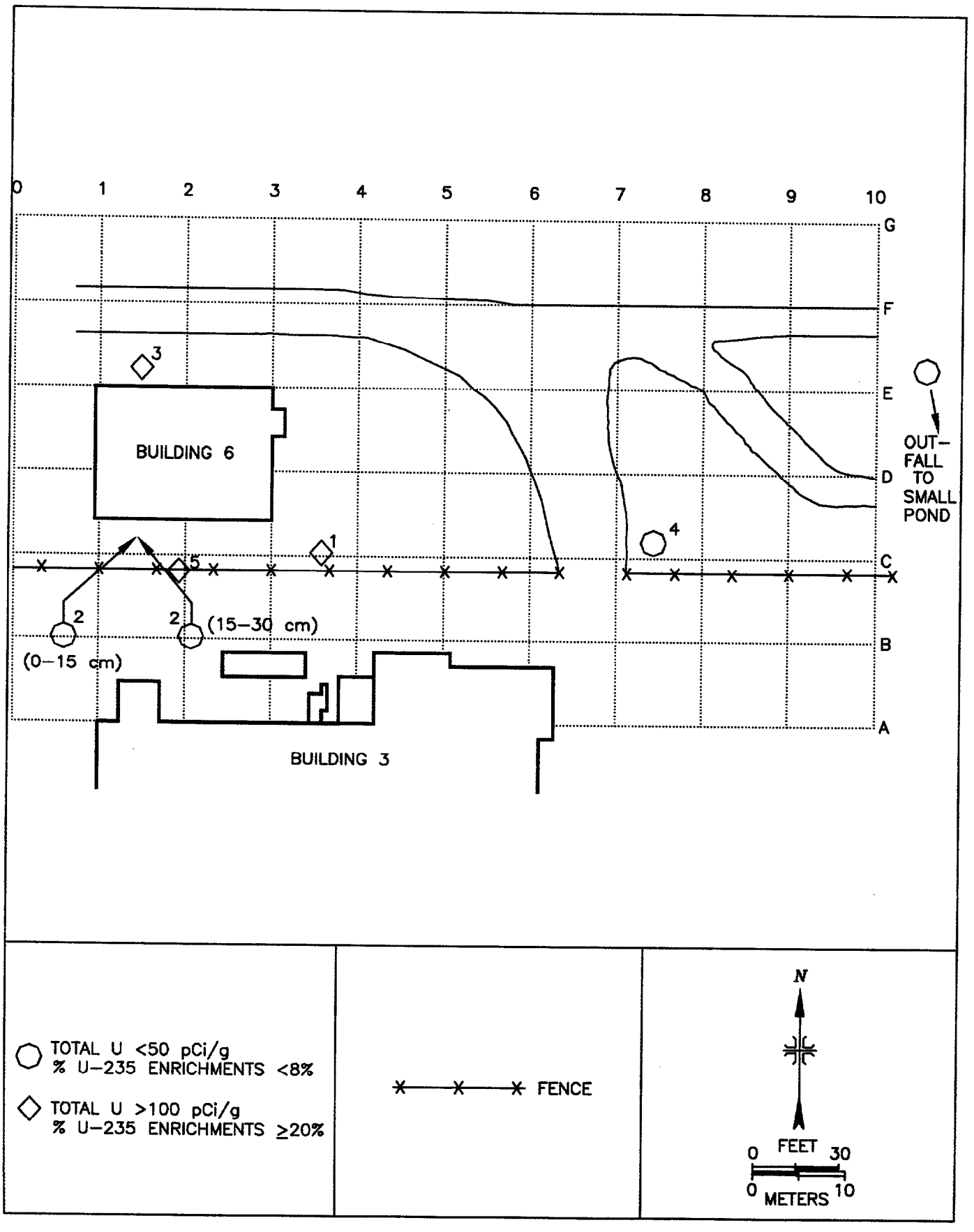


FIGURE 11: Grounds North of Building 3 – Measurement and Sampling Locations

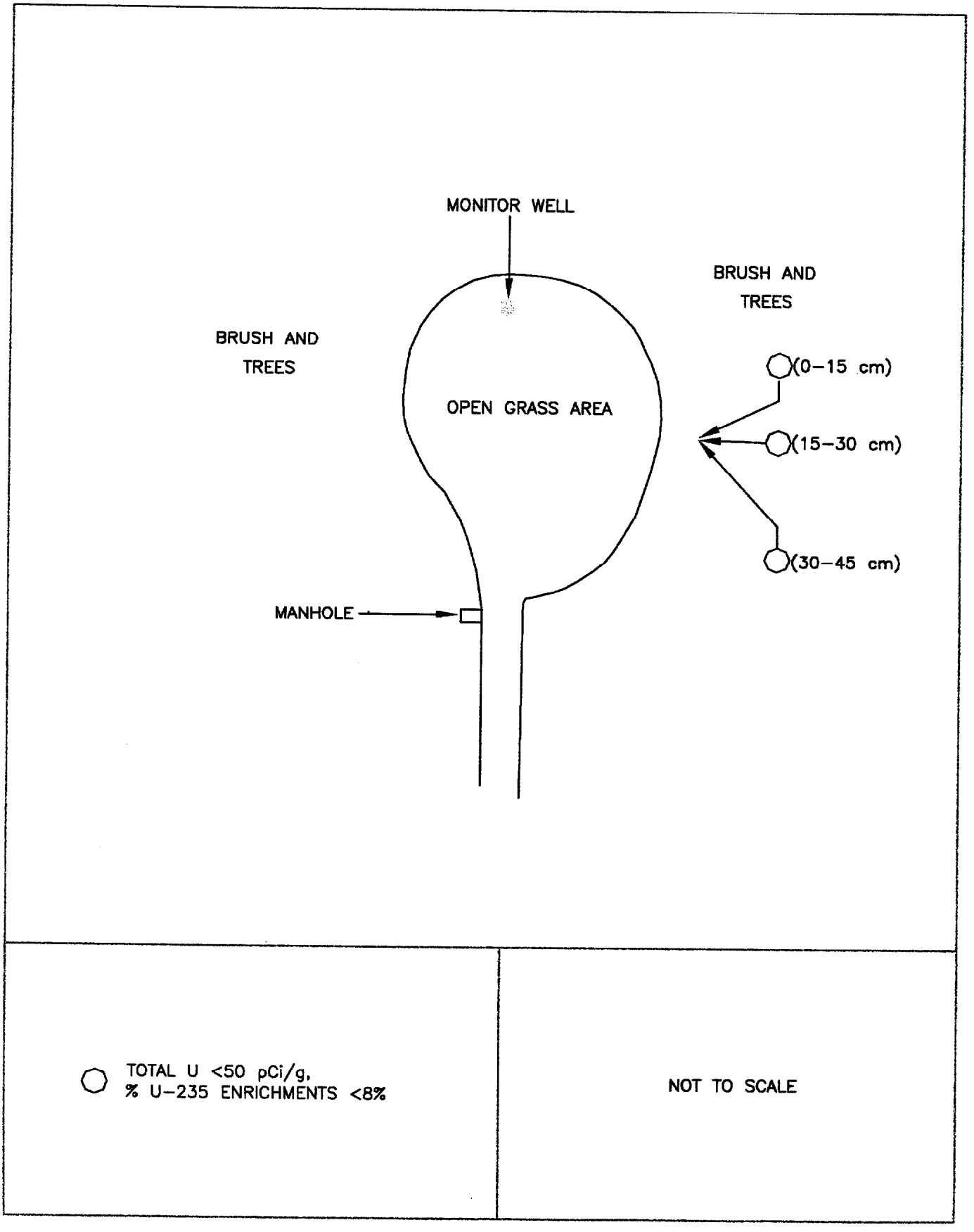


FIGURE 12: Septic Field – Measurement and Sampling Locations

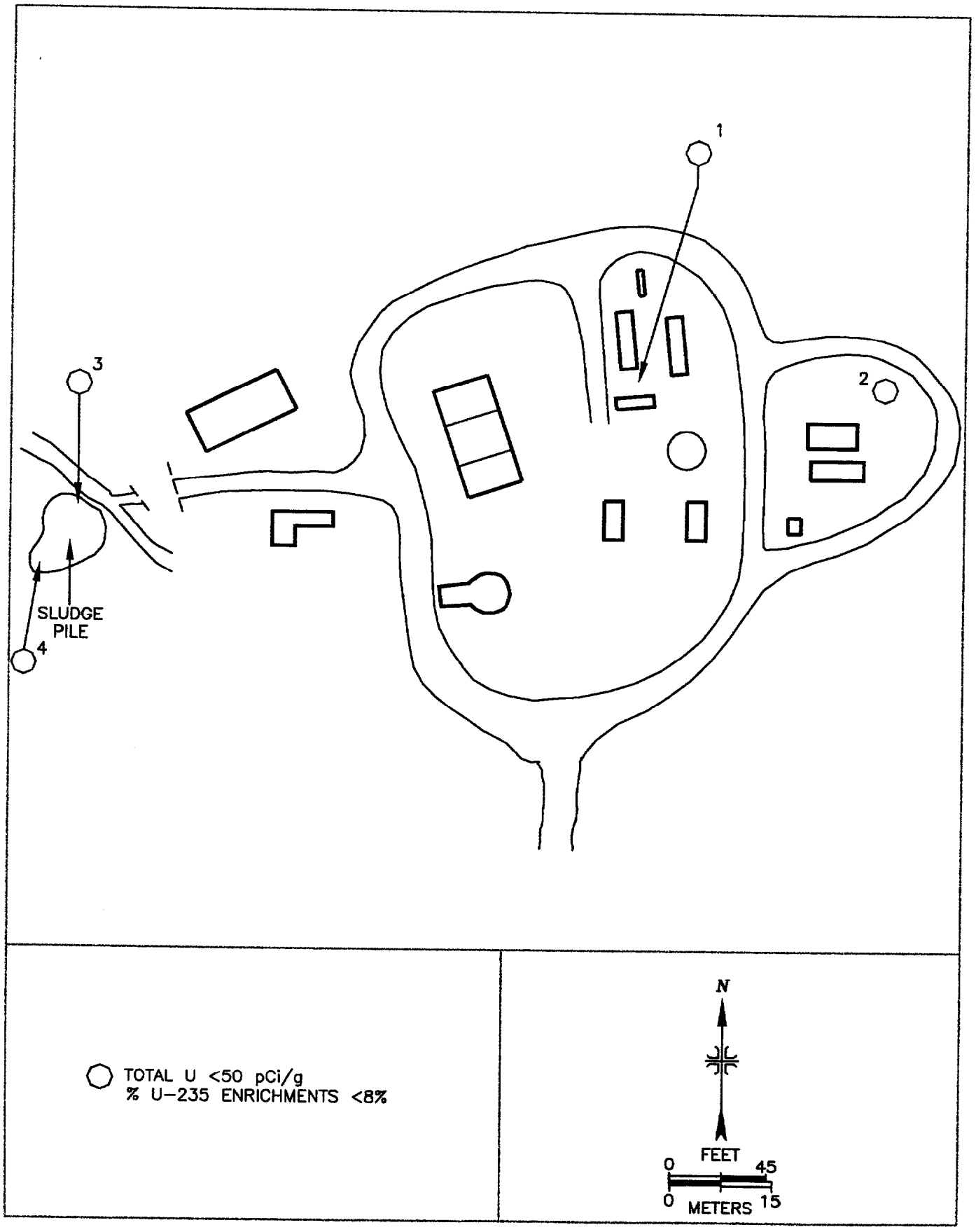
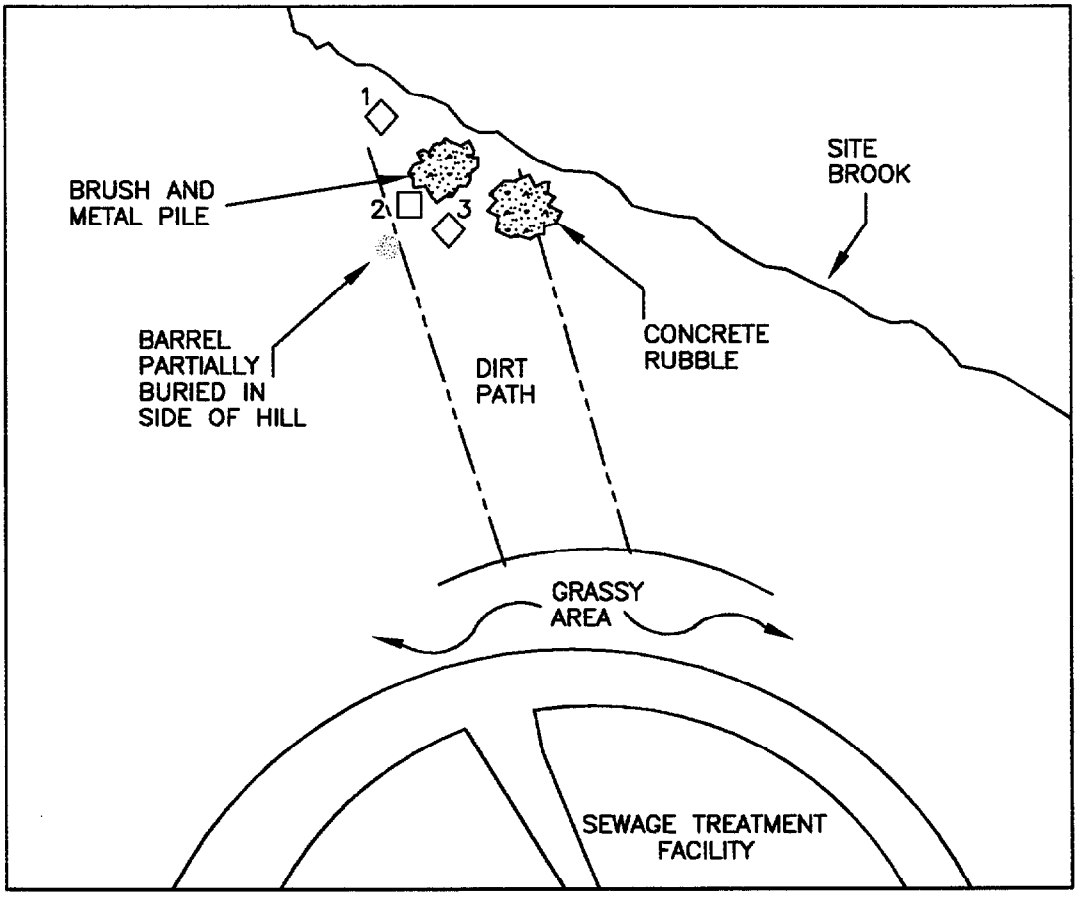


FIGURE 13: Sewage Treatment Facility – Measurement and Sampling Locations



◇ TOTAL U >100 pCi/g
% U–235 ENRICHMENTS ≥20%

□ TOTAL U >100 pCi/g
% U–235 ENRICHMENTS
BETWEEN 15 AND 20%

N

NOT TO SCALE

FIGURE 14: Trash Piles on Site Brook Bank – Measurement and Sampling Locations

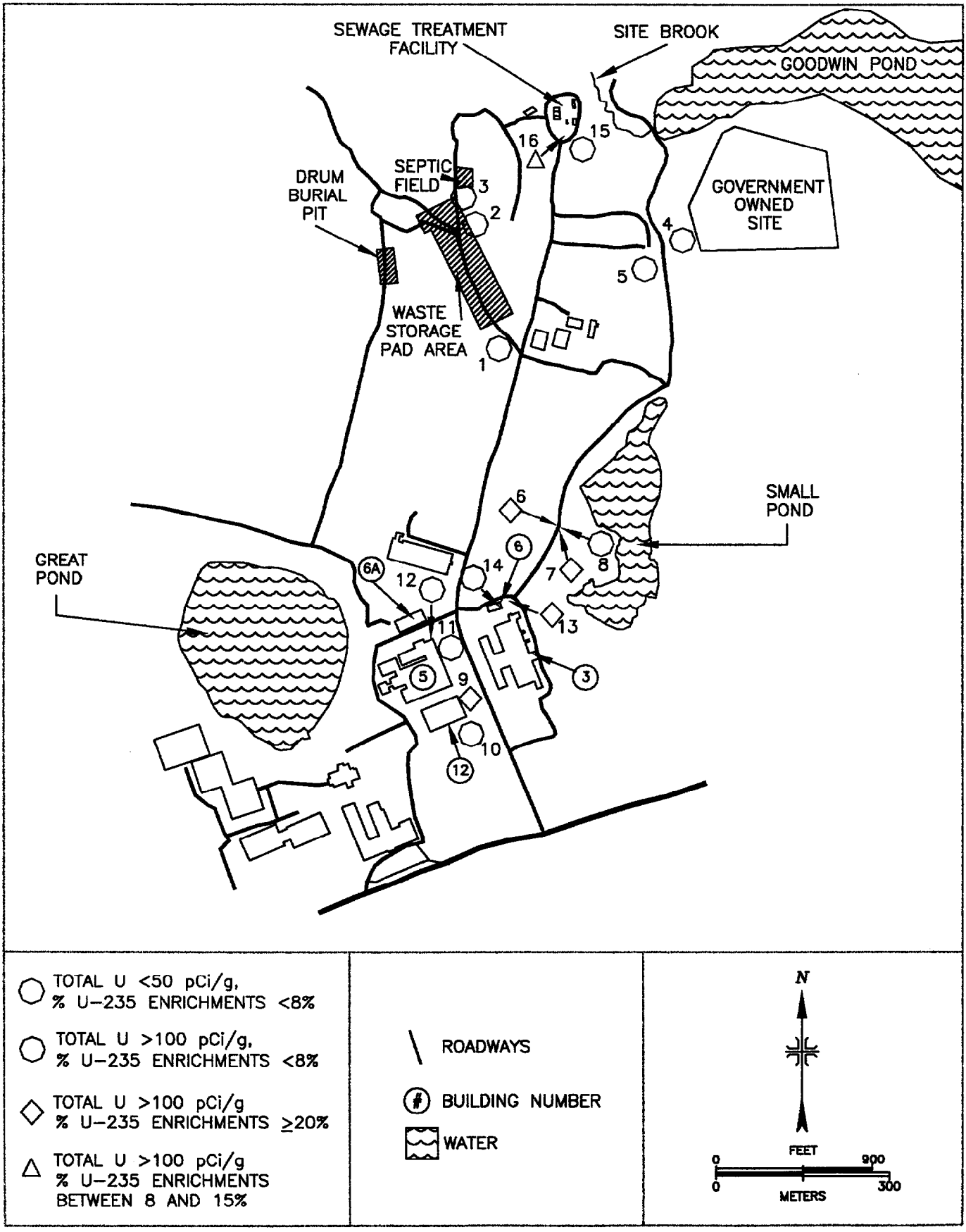


FIGURE 15: Sewer Line Manholes – Measurement and Sampling Locations

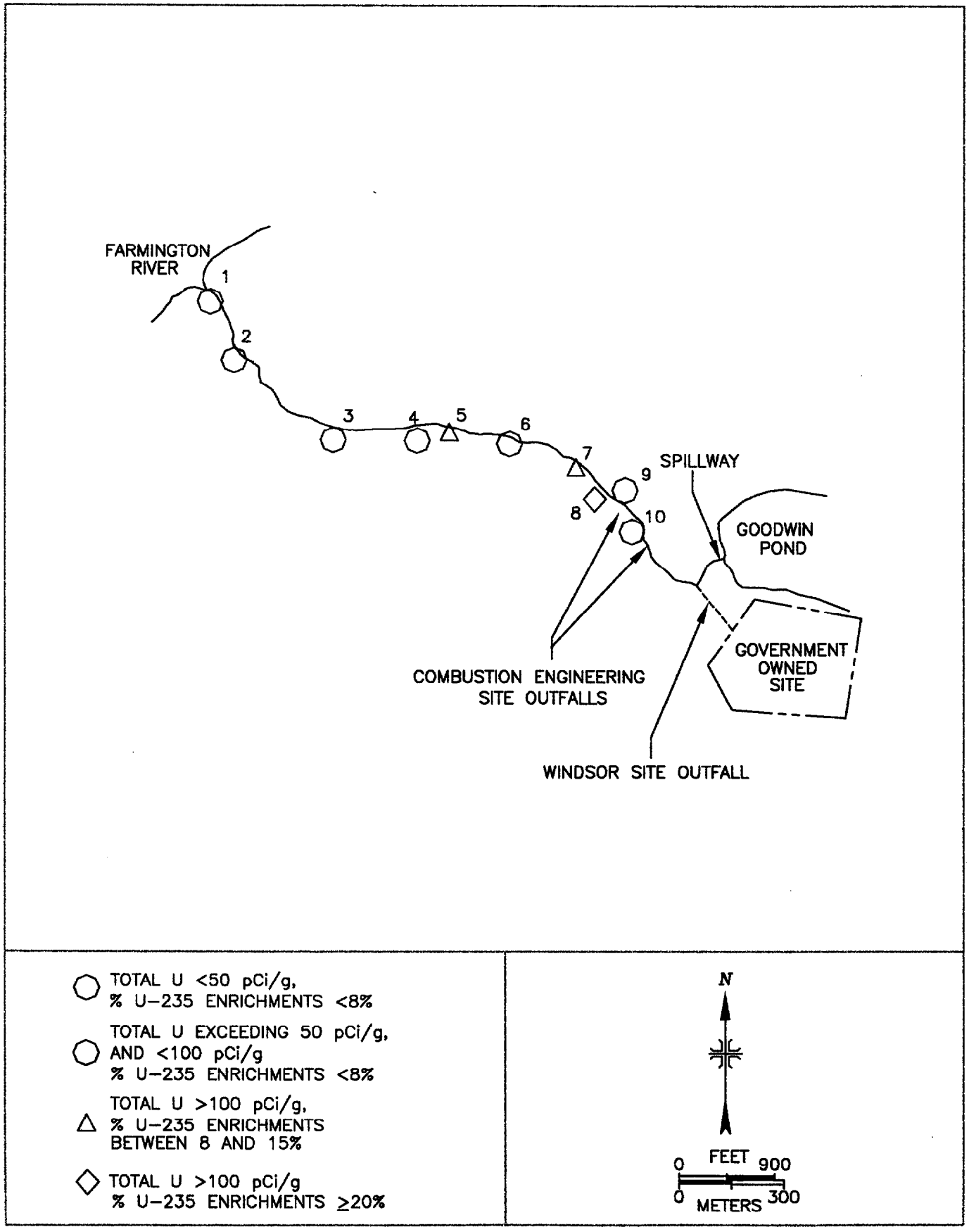


FIGURE 16: Site Brook – ORISE Sampled Locations

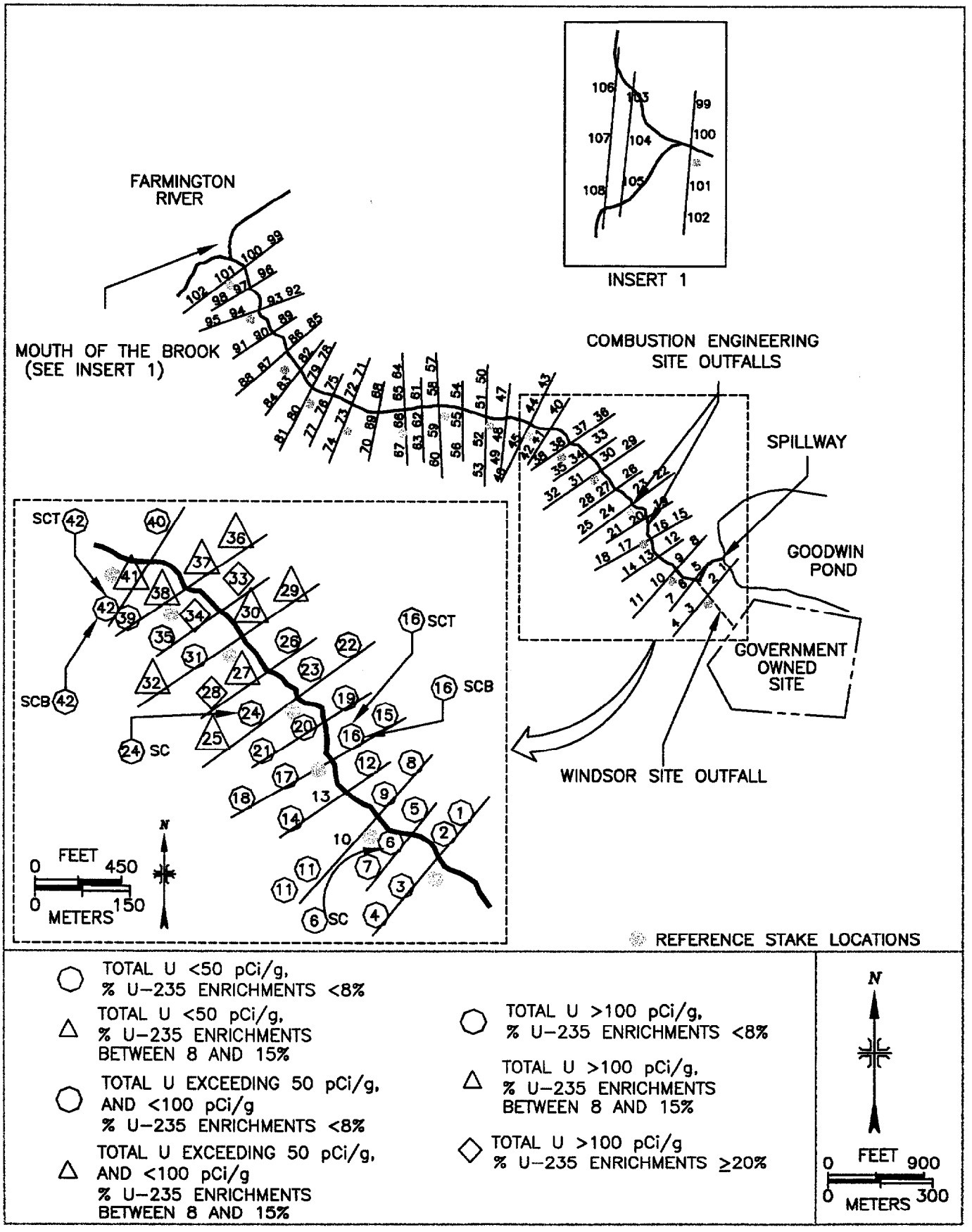


FIGURE 17: Site Brook – KAPL Sampled Locations Near Plant Discharge

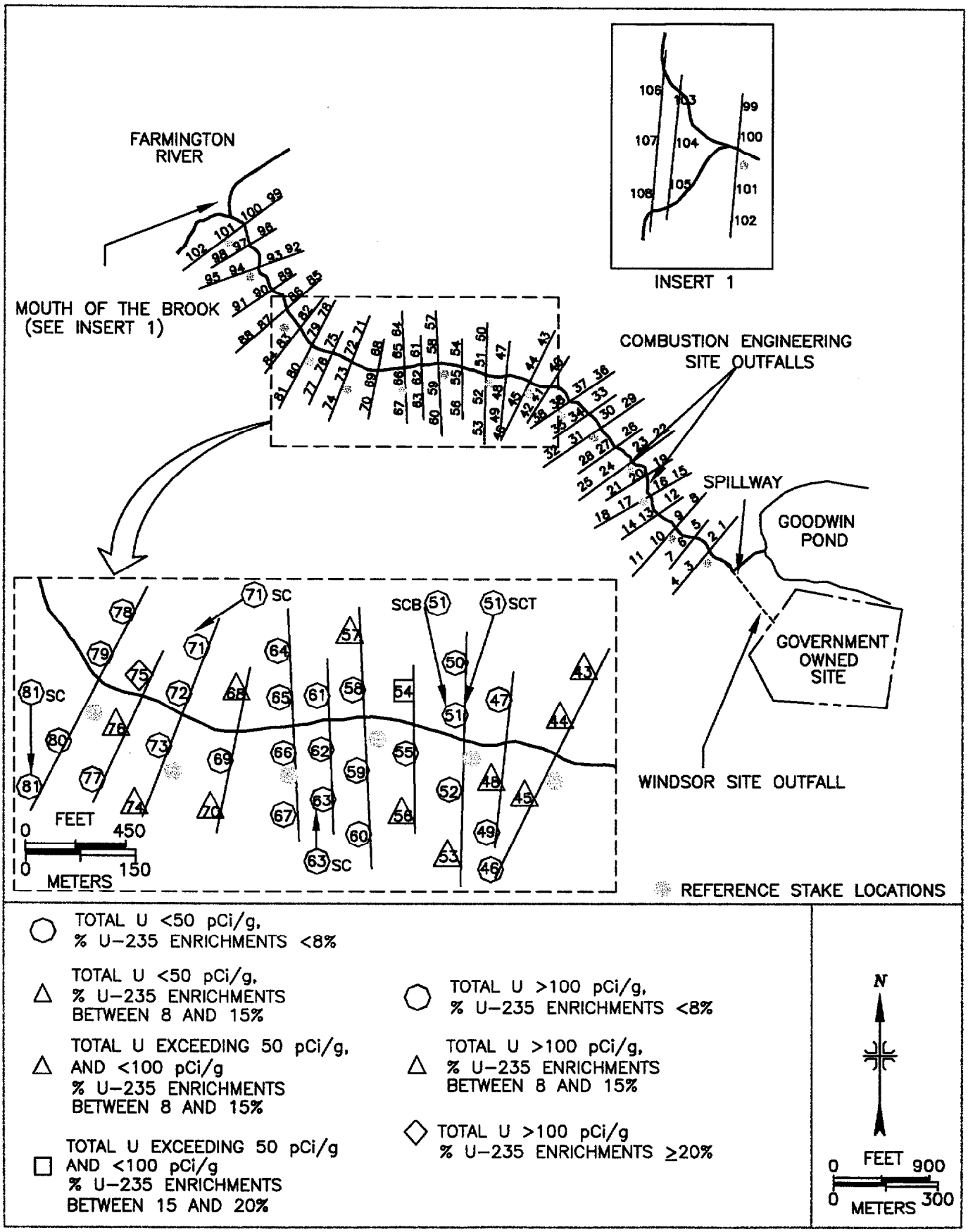


FIGURE 18: Site Brook – KAPL Sampled Locations Middle Of Brook

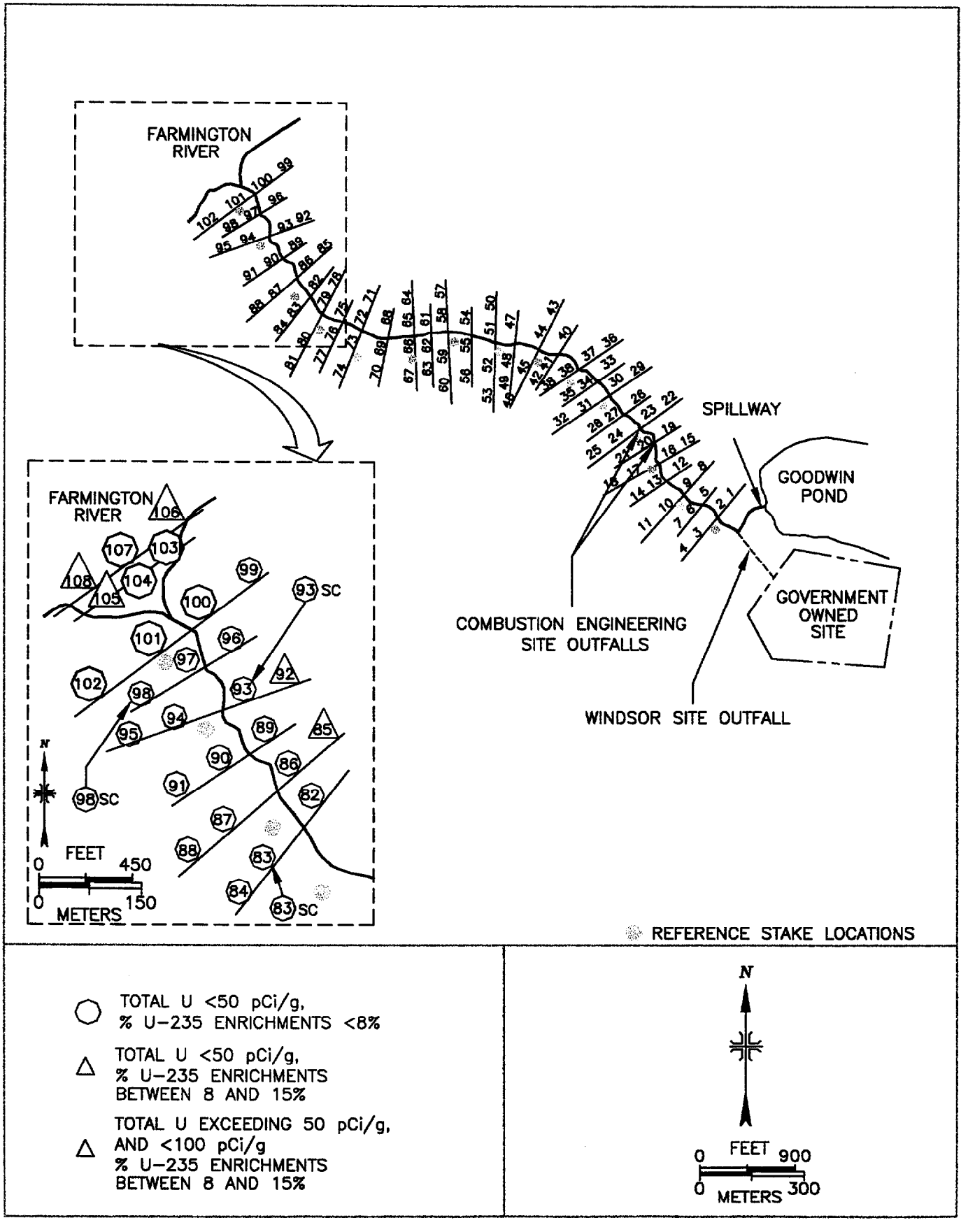


FIGURE 19: Site Brook – KAPL Sampled Locations Near Farmington River

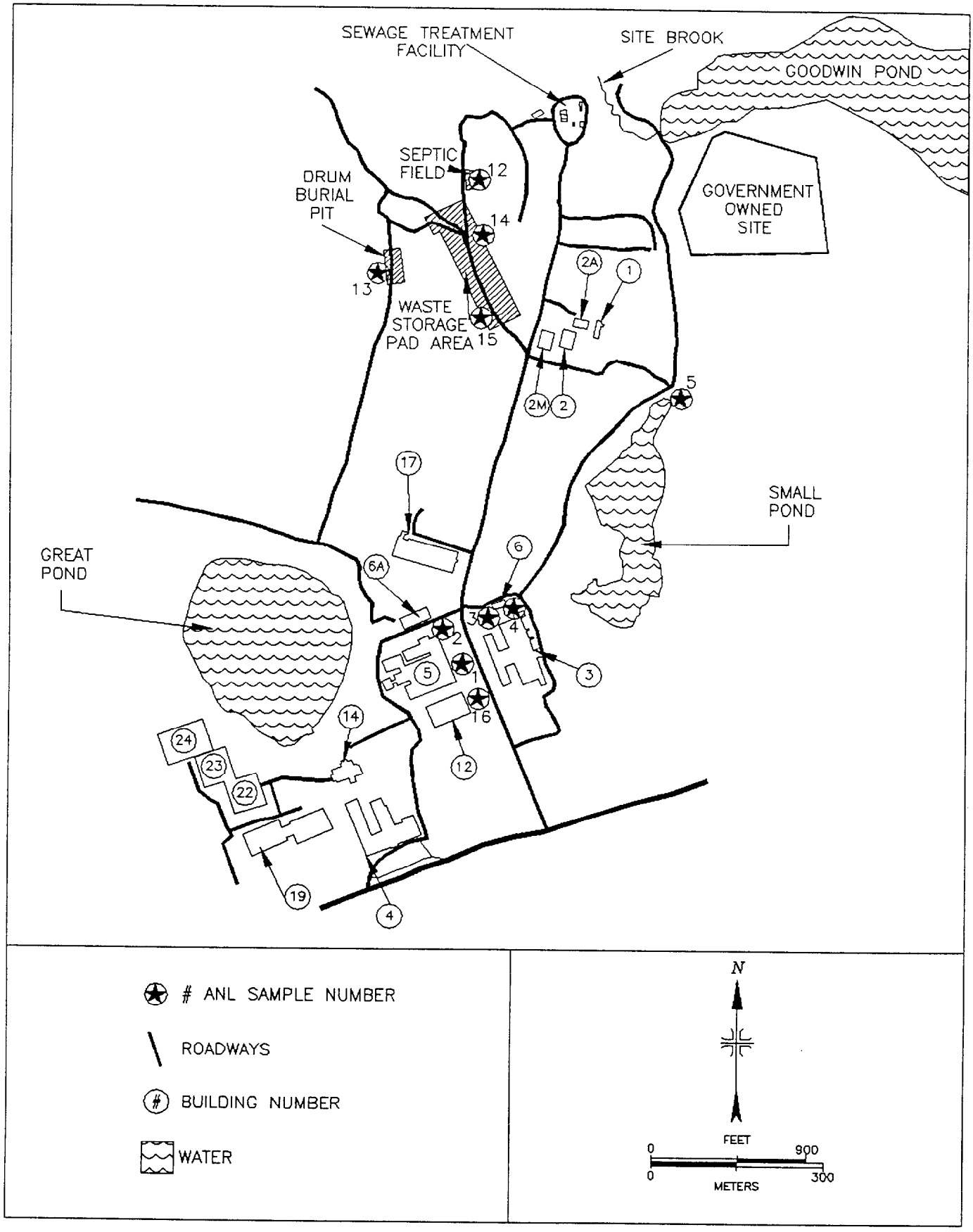


FIGURE 20: Argonne National Laboratory Sampling Locations for Environmental Samples

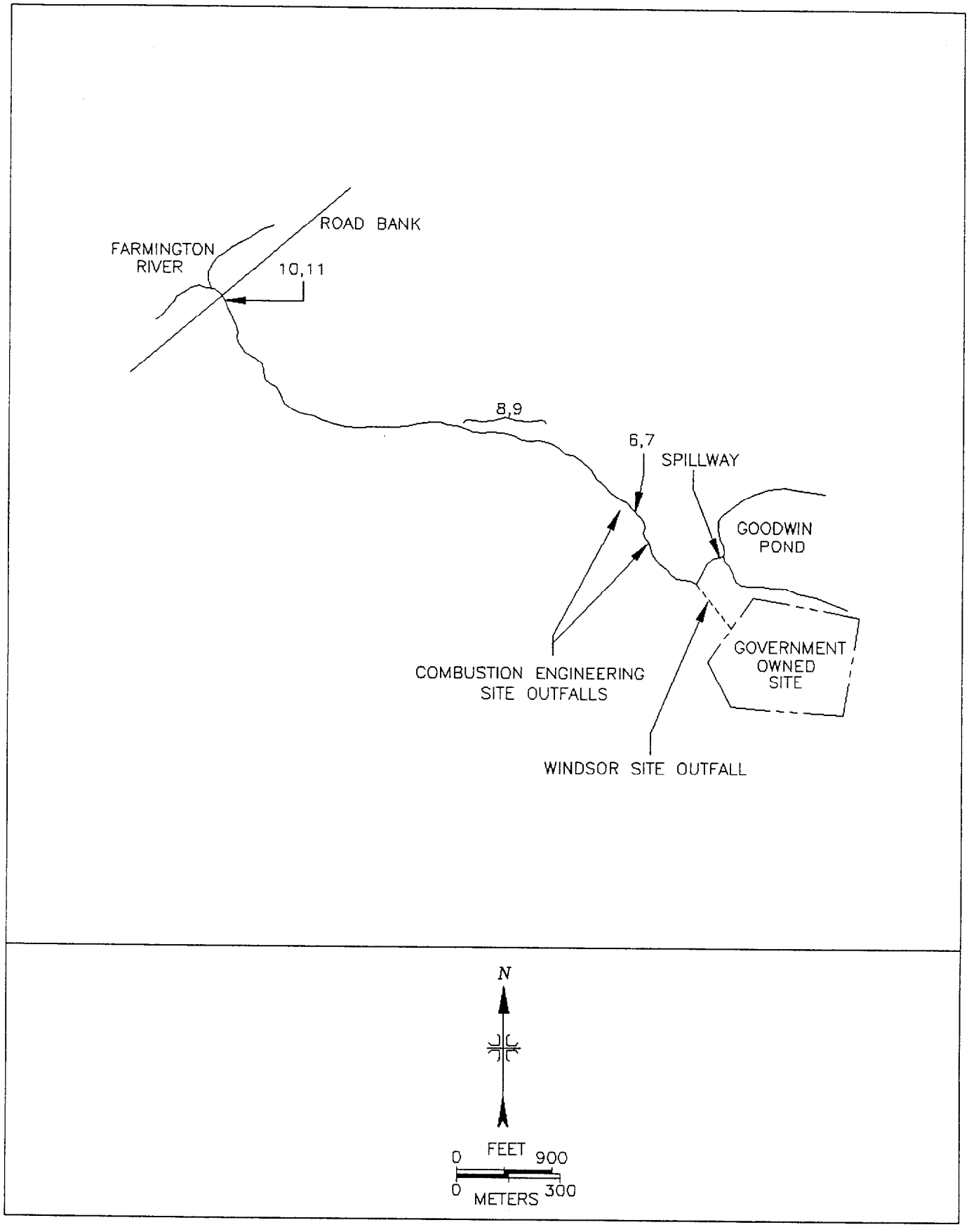


FIGURE 21: Argonne National Laboratoy Sampling Locations at the Site Brook

TABLE 1

URANIUM CONCENTRATIONS IN MISCELLANEOUS SAMPLES
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Sample Type	Figure No.	Uranium Concentrations (pCi/g)			% U-235 Enrichment
			U-235	U-238	Total U[a]	
Building 3						
Drain #2	Residue	3	<1.3	14.9 ± 9.3[b]	47	1.3
Drain #3	Residue	3	0.4 ± 0.1	2.1 ± 1.8	12	2.9
Drain #4	Residue	3	0.6 ± 0.1	2.2 ± 1.5	17	4.0
Roof Vent, 3rd from N. End	Residue	N/A	<2.3	<17	74	2.1
Roof Vent, 7th from N. End	Residue	N/A	0.8 ± 0.3	5.0 ± 3.7	25	2.4
Drop Tube Furnace #1	Pipe Insulation	6	97.8 ± 5.9	61 ± 33	2,500	20
W. Wall #3	Fiberglass	6	<35[c]	780 ± 490[c]	1,600	0.68
Building 6						
Near Pump Stand	Residue	8	385.5 ± 6.5	1418 ± 47	11,000	4.0
Drum Burial Pit						
Adjacent to Surface Soil #2	Plastic	11	307,400 ± 2,800[c]	<19,000[c]	7.8E6	71

[a]Total uranium concentration based on an assumed U-234 to U-235 ratio of 24.
[b]Uncertainties represent the 95% confidence level, based on counting statistics only.
[c]Units of pCi/sample.

TABLE 2

URANIUM CONCENTRATIONS IN SOIL SAMPLES
WASTE STORAGE PAD AREA
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Depth of Sample (cm)	Uranium Concentrations (pCi/g)			% U-235 Enrichment
		U-235	U-238	Total U[b]	
Waste Storage Pad Area[a]					
Grid F3	0-15	0.4 ± 0.1[c]	1.9 ± 1.5	12	3.1
F3	15-30	<0.1	<1.5	4.0	1.0
F3	30-45	<0.1	1.9 ± 1.7	4.4	0.80
AA5	0-15	16.6 ± 0.4	<2.7	420	48
EE0	0-15	41.8 ± 0.6	5.8 ± 2.5	1,100	52
CC5	0-15	2169.0 ± 9.0	<72	54,000	82
CC5	15-30	77.7 ± 0.8	<5.3	1,900	69
A6	0-15	316.3 ± 1.4	11.1 ± 4.7	7,900	81
C6	0-15	724.9 ± 2.2	25.2 ± 8.0	18,000	81
C6	15-30	247.1 ± 2.4	<16	6,200	70
E6	0-15	98.6 ± 0.8	<4.9	2,500	75
H8	15-30	<0.1	1.6 ± 1.0	4.1	0.95
D8	0-15	358.2 ± 1.6	<8.7	9,000	86
L9	15-30	0.9 ± 0.1	<1.4	24	9.0

[a]Refer to Figure 9.
[b]Total uranium concentration based on an assumed U-234 to U-235 ratio of 24.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 3

URANIUM CONCENTRATIONS IN SOIL SAMPLES
DRUM BURIAL PIT AND OTHER SITE AREAS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location		Depth of Sample (cm)	Uranium Concentrations (pCi/g)			% U-235 Enrichment
			U-235	U-238	Total U[a]	
Drum Burial Pit[b]						
Location	1	0-15	<0.1	<1.1	3.6	1.4
	3	15-30	23.9 ± 0.4[c]	<3.3	600	53
(inside drum)	5	0-15	620.1 ± 2.5	20.6 ± 8.9	16,000	82
	6	0-30	30.1 ± 0.5	<3.4	760	57
Grounds North of Building 3[d]						
Location	2	15-30	0.7 ± 0.1	1.7 ± 1.1	19	6.0
	3	0-15	148.0 ± 1.1	<7.7	3,700	74
	4	0-15	<0.1	2.7 ± 1.3	5.2	0.57
Septic Field[e]						
Location	1	0-15	<0.1	1.3 ± 1.8	3.8	1.2
	1	15-30	<0.3	<4.0	12	1.1
	1	30-45	<0.2	<2.5	7.5	1.2
Sewage Treatment Facility and Sludge Piles[f]						
Location	1	0-15	<0.1	<1.8	4.3	0.85
	2	0-15	<0.1	<1.4	3.9	1.1
	3	0-15	<0.2	<1.8	6.8	1.7
	4	0-15	1.2 ± 0.3	9.5 ± 5.4	40	1.9

[a]Total uranium concentration based on an assumed U-234 to U-235 ratio of 24.
[b]Refer to Figure 10.
[c]Uncertainties represent the 95% confidence level, based only counting statistics.
[d]Refer to Figure 11.
[e]Refer to Figure 12.
[f]Refer to Figure 13.

TABLE 4

URANIUM CONCENTRATIONS IN SEDIMENT SAMPLES FROM MANHOLE ACCESS LOCATIONS COMBUSTION ENGINEERING SITE WINDSOR, CONNECTICUT

Location	Uranium Concentrations (pCi/g)			% U-235 Enrichment
	U-235	U-238	Total U[b]	
Manholes[a]				
1	<0.2	2.4 ± 1.6[c]	7.4	1.3
2	<0.1	0.6 ± 0.9	3.1	2.5
3	<0.2	<2.3	7.3	1.3
4	1.0 ± 0.1	2.1 ± 1.1	27	6.8
5	<0.1	2.5 ± 1.3	5.0	0.61
7	565.5 ± 1.9	64.7 ± 9.8	14,000	57
8	<0.1	<1.6	4.1	0.95
10	<0.2	1.3 ± 1.1	6.3	2.3
12	349.9 ± 4.1	1727 ± 58	10,000	3.0
13	3868 ± 39	<210	97,000	74
14	146.3 ± 3.8	459 ± 43	4,100	4.7
15	0.3 ± 0.1	1.8 ± 0.9	9.3	2.5

[a]Refer to Figure 15.
[b]Total uranium concentration calculated based on an assumed U-234 to U-235 ratio of 24.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 5

URANIUM CONCENTRATIONS IN SEDIMENT SAMPLES FROM SITE BROOK AND OUTFALL TO SMALL POND COMBUSTION ENGINEERING SITE WINDSOR, CONNECTICUT

Location	Uranium Concentrations (pCi/g)			% U-235 Enrichment
	U-235	U-238	Total U[a]	
Site Brook[b]				
1	<0.1	<1.0	3.5	1.5
2	<0.1	1.2 ± 1.1[c]	3.7	1.3
3	<0.1	1.3 ± 0.8	3.8	1.2
4	0.1 ± 0.1	0.5 ± 0.7	3.0	3.0
5	10.9 ± 0.6	11.3 ± 4.8	280	13
6	1.5 ± 0.1	3.4 ± 1.2	41	6.4
7	16.7 ± 1.0	21 ± 10	440	11
9	2.3 ± 0.2	8.6 ± 2.9	66	4.0
10	1.0 ± 0.1	2.0 ± 1.7	27	7.2
Outfall to Small Pond[d]				
Outfall	<0.1	<1.0	3.5	1.5

[a]Total uranium concentration based on assumed U-234 to U-235 ratio of 24.
[b]Refer to Figure 16. The results for Location #8 are shown in Table 6.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Refer to Figure 11.

TABLE 6

ISOTOPIC URANIUM CONCENTRATIONS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Figure No.	Uranium Concentrations (pCi/g)				% U-235 Enrichment
		U-234	U-235	U-238	Total U[a]	
Bldg 3, Drain #1	3	12,640 ± 250[b]	465 ± 55	91 ± 22	13,190 ± 260	44
Bldg 3, High Bay, W. Wall	4	0.95 ± 0.13	0.02 ± 0.04	0.63 ± 0.10	1.60 ± 0.16	0.59
Bldg 3, E. Wall #1	5	48.13 ± 0.65	1.72 ± 0.14	1.10 ± 0.10	50.95 ± 0.67	20
Bldg 3, E. Wall #2	5	577.42 ± 9.57	19.16 ± 1.98	4.75 ± 0.89	601.33 ± 9.82	38
Bldg 3, E. Wall #3	5	1.28 ± 0.11	0.05 ± 0.02	0.73 ± 0.08	2.06 ± 0.13	0.94
Bldg 3, Drop Tube Furnace #2	6	10.48 ± 0.35	0.46 ± 0.08	0.50 ± 0.08	11.44 ± 0.37	12
Bldg 3, S. Wall	N/A	1.30 ± 0.12	0.07 ± 0.3	0.91 ± 0.10	2.28 ± 0.16	1.1
Bldg 3, N. Wall #1	7	782 ± 24	61.3 ± 7.6	20.0 ± 3.8	864 ± 25	32
Bldg 3, N. Wall #2	7	42.0 ± 1.8	1.53 ± 0.39	0.28 ± 0.16	43.8 ± 1.8	46
Bldg 6, N.E. Corner Floor	8	8,910 ± 460	351 ± 47	499 ± 53	9,760 ± 460	9.9
Bldg 6, Sump	8	12,780 ± 410	512 ± 92	554 ± 85	13,850 ± 430	13
Waste Storage Pad AA5, 15-30 cm	9	51.8 ± 1.2	2.49 ± 0.29	0.81 ± 0.15	55.1 ± 1.2	32
Waste Storage Pad A6, 15-30 cm	9	70.2 ± 1.3	3.17 ± 0.32	0.60 ± 0.12	74.0 ± 1.4	45
Waste Storage Pad E6, 15-30 cm	9	41.87 ± 0.97	2.00 ± 0.24	0.86 ± 0.14	44.7 ± 1.0	27
Waste Storage Pad EE0, 15-30 cm	9	1,119 ± 25	39.6 ± 5.3	15.0 ± 2.9	1,173 ± 25	29
Waste Storage Pad D8, 15-30 cm	9	611 ± 11	22.1 ± 2.4	3.69 ± 0.90	636 ± 12	48
Waste Storage Pad H4, 0-15 cm	9	319 ± 26	12.9 ± 2.4	2.12 ± 0.86	334 ± 27	49
Waste Storage Pad H4, 15-30 cm	9	57.7 ± 2.2	2.05 ± 0.47	1.06 ± 0.30	60.8 ± 2.2	23
Waste Storage Pad H8, 0-15 cm	9	436 ± 27	15.8 ± 2.7	2.32 ± 0.90	454 ± 27	51
Waste Storage Pad K6, 15-30 cm	9	19.68 ± 0.68	1.07 ± 0.18	0.27 ± 0.08	21.02 ± 0.70	38

TABLE 6 (Continued)

ISOTOPIC URANIUM CONCENTRATIONS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Figure No.	Uranium Concentrations (pCi/g)				% U-235 Enrichment
		U-234	U-235	U-238	Total U[a]	
Waste Storage Pad K6, 0-15 cm	9	2,330 ± 160	89 ± 16	7.4 ± 4.0	2,430 ± 160	65
Waste Storage Pad L9, 0-15 cm	9	70.4 ± 7.2	3.7 ± 1.2	1.04 ± 0.59	75.2 ± 7.3	36
Drum Burial Pit #2, 0-15 cm	10	882 ± 21	31.2 ± 4.5	3.5 ± 1.3	917 ± 22	58
Drum Burial Pit #3, 0-15 cm	10	328 ± 28	15.1 ± 2.8	2.02 ± 0.84	345 ± 28	53
Drum Burial Pit #4, 0-15 cm	10	23.5 ± 1.6	1.48 ± 0.46	0.48 ± 0.23	25.5 ± 1.7	33
N. of Bldg 3 #1, 0-15 cm	11	712 ± 20	44.0 ± 5.7	12.0 ± 2.6	768 ± 21	36
N. of Bldg 3 #2, 0-15 cm	11	31.1 ± 1.5	1.61 ± 0.39	6.42 ± 0.69	39.1 ± 1.7	3.7
N. of Bldg 3 #5	11	568 ± 34	27.1 ± 3.6	6.6 ± 1.5	601 ± 34	39
Site Brook Bank #1	14	929 ± 74	37 ± 10	0.9 ± 1.5	967 ± 75	86
Site Brook Bank #2, 0-15 cm	14	15,450 ± 320	4,860 ± 200	3,780 ± 160	24,090 ± 410	17
Site Brook Bank #3	14	387 ± 33	22.0 ± 3.5	9.1 ± 1.9	418 ± 33	27
Manhole #6, Old Industrial Line	15	4,680 ± 170	185 ± 38	36 ± 15	4,900 ± 170	44
Manhole #9, Industrial	15	1,989 ± 87	71 ± 19	8.8 ± 5.8	2,069 ± 89	55
Manhole #11, Industrial	15	355 ± 33	14.5 ± 2.9	25.6 ± 3.9	395 ± 33	8.0
Manhole #16, Industrial	15	310 ± 14	11.5 ± 3.0	11.8 ± 2.7	334 ± 14	13
Site Brook #8	16	16,160 ± 370	525 ± 75	59 ± 22	16,740 ± 380	58

[a]Total uranium concentrations based on the sum of U-234, U-235 and U-238 concentrations.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL Id[d, e]	ORISE Sample ID	Radionuclide Concentration (pCi/g)					% U-235 Enrichment
		U-235	U-238	Total U[a]	Co-60[b] (1173 keV)	Co-60[b] (1332 keV)	
S1	390S117	0.00	0.73 ± 0.76[c]	0.7	0.11	0.00	0.0
S2	390S001	0.00	0.37 ± 0.78	0.4	0.16	0.00	0.0
S3	390S002	0.00	0.63 ± 0.78	0.6	0.17 ± 0.11	0.17 ± 0.11	0.0
S4	390S003	0.00	0.35 ± 0.86	0.4	0.25	0.00	0.0
S5	390S004	0.00	0.80 ± 0.71	0.8	0.37 ± 0.16	0.49 ± 0.14	0.0
S6	390S005	0.00	1.07 ± 1.74	1.1	5.78 ± 0.73	4.77 ± 0.72	0.0
SC6	390S116	0.00	6.19 ± 1.99	6.2	46.67 ± 1.92	46.90 ± 1.88	0.0
S7	390S006	0.00	0.71 ± 2.15	0.7	29.63 ± 1.53	28.81 ± 1.48	0.0
S8	390S007	0.00	1.33 ± 1.92	1.3	5.33 ± 0.68	5.92 ± 0.69	0.0
S9	390S008	0.00	3.72 ± 2.79	3.7	13.43 ± 1.26	13.02 ± 1.17	0.0
S11	390S009	0.30 ± 0.12	4.36 ± 1.53	11.8	1.81 ± 0.31	1.84 ± 0.33	1.04
SC11	390S102	0.00	0.92 ± 0.92	0.9	0.25	0.00	0.0
S12	390S010	0.00	2.61 ± 1.26	2.6	2.23 ± 0.43	2.44 ± 0.39	0.0
S14	390S011	0.00	1.89 ± 1.29	1.9	1.39 ± 0.33	0.87 ± 0.30	0.0
S15	390S012	0.00	2.79 ± 1.73	2.8	5.09 ± 0.82	5.24 ± 0.70	0.0
S16	390S013	0.00	2.76 ± 1.03	2.8	0.88 ± 0.22	1.02 ± 0.18	0.0
SC16B	390S103	0.72 ± 0.10	11.99 ± 1.37	30.0	0.54 ± 0.31	0.74 ± 0.21	0.92
SC16T	390S104	0.00	5.62 ± 1.54	5.6	2.10 ± 0.45	1.69 ± 0.37	0.0
S17	390S014	0.95 ± 0.22	5.67 ± 2.53	29.4	4.11 ± 0.76	4.44 ± 0.81	2.54
S18	390S015	0.25 ± 0.11	2.97 ± 1.47	9.3	8.70 ± 0.69	7.98 ± 0.68	1.32
S19	390S016	4.97 ± 0.29	15.33 ± 2.61	139.6	13.95 ± 1.12	13.12 ± 1.08	4.80
S20	390S017	0.62 ± 0.08	2.16 ± 1.04	17.7	0.29 ± 0.25	0.12 ± 0.12	4.28
S21	390S018	0.79 ± 0.16	7.63 ± 2.07	27.4	1.78 ± 0.47	1.97 ± 0.56	1.59
S22	390S019	1.76 ± 0.32	11.05 ± 2.73	55.2	2.69 ± 0.74	2.49 ± 0.77	2.42
S23	390S020	2.69 ± 0.18	11.33 ± 1.98	78.5	17.88 ± 0.95	16.36 ± 0.97	3.56
SC24	390S105	0.49 ± 0.07	2.25 ± 0.78	14.5	0.20 ± 0.22	0.41 ± 0.16	3.29
S24	390S021	1.80 ± 0.14	7.54 ± 1.59	52.5	1.76 ± 0.37	1.92 ± 0.36	3.58
S25	390S022	1.45 ± 0.09	1.49 ± 0.82	37.8	0.45 ± 0.18	0.41 ± 0.17	13.14

TABLE 7 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL Id[d, e]	ORISE Sample ID	Radionuclide Concentration (pCi/g)					% U-235 Enrichment
		U-235	U-238	Total U[a]	Co-60[b] (1173 keV)	Co-60[b] (1332 keV)	
S26	390S023	7.13 ± 0.50	24.39 ± 4.26	202.7	5.74 ± 1.09	7.35 ± 1.20	4.35
S27	390S118	12.93 ± 0.54	11.82 ± 3.76	335.1	34.38 ± 2.08	33.91 ± 1.98	14.53
S28	390S119	16.48 ± 0.23	1.29 ± 1.40	413.3	0.73 ± 0.15	0.59 ± 0.17	66.12
S29	390S024	4.17 ± 0.19	6.67 ± 1.56	110.9	3.03 ± 0.40	2.36 ± 0.40	8.86
S30	390S025	4.42 ± 0.24	6.77 ± 1.75	117.2	2.44 ± 0.42	2.53 ± 0.39	9.22
S31	390S026	1.02 ± 0.06	0.65 ± 0.62	26.1	0.26 ± 0.12	0.15 ± 0.08	19.63
S32	390S027	14.26 ± 0.60	18.62 ± 4.05	375.1	5.13 ± 0.96	5.47 ± 0.94	10.64
S33	390S120	27.34 ± 0.62	5.36 ± 2.64	688.9	4.66 ± 0.82	4.90 ± 0.67	44.11
S34	390S028	5.04 ± 0.19	2.61 ± 1.22	128.6	0.74 ± 0.31	0.40 ± 0.18	23.04
S35	390S029	7.53 ± 0.33	16.94 ± 2.75	205.2	4.89 ± 0.73	4.97 ± 0.71	6.47
S36	390S030	2.05 ± 0.16	3.69 ± 1.10	54.9	1.28 ± 0.35	1.07 ± 0.27	7.95
S37	390S031	2.44 ± 0.14	3.19 ± 1.02	64.2	0.72 ± 0.25	0.70 ± 0.21	10.61
S38	390S032	4.22 ± 0.26	7.93 ± 1.91	113.3	2.07 ± 0.42	2.30 ± 0.42	7.64
S39	390S033	0.56 ± 0.08	1.76 ± 1.16	15.7	0.24	0.00	4.69
S40	390S034	3.87 ± 0.20	1.34 ± 1.17	7.0	0.29	0.00	2.59
S41	390S035	3.87 ± 0.20	4.01 ± 1.51	100.7	1.93 ± 0.46	2.09 ± 0.39	13.04
S42	390S036	0.96 ± 0.07	2.38 ± 0.97	26.4	0.35 ± 0.16	0.32 ± 0.13	5.90
SC42B	390S106	0.00	0.88 ± 0.62	0.9	0.10	0.00	0.0
SC42T	390S107	0.48 ± 0.08	2.01 ± 0.98	14.0	0.23	0.00	3.57
S43	390S037	8.72 ± 0.41	16.27 ± 3.28	234.3	5.15 ± 0.87	5.17 ± 0.77	7.69
S44	390S038	7.53 ± 0.28	12.64 ± 2.23	200.8	3.47 ± 0.56	3.53 ± 0.46	8.47
S45	390S039	0.31 ± 0.06	0.56 ± 0.71	8.3	0.17	0.00	7.94
S46	390S040	0.51 ± 0.09	1.67 ± 1.10	14.3	0.37 ± 0.21	0.37 ± 0.15	4.51
S47	390S041	0.82 ± 0.06	1.62 ± 0.69	22.2	0.44 ± 0.16	0.38 ± 0.13	7.32
S48	390S042	0.80 ± 0.07	1.11 ± 0.69	21.1	0.73 ± 0.18	0.59 ± 0.17	10.10
S49	390S043	0.36 ± 0.07	1.12 ± 0.93	10.2	0.29	0.00	4.81
S50	390S044	0.24 ± 0.08	1.58 ± 0.75	7.5	0.23	0.00	2.30
S51	390S045	0.21 ± 0.05	1.03 ± 0.82	6.2	0.17	0.00	3.06

TABLE 7 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL Id[d, e]	ORISE Sample ID	Radionuclide Concentration (pCi/g)					% U-235 Enrichment
		U-235	U-238	Total U[a]	Co-60[b] (1173 keV)	Co-60[b] (1332 keV)	
SC51B	390S108	0.00	2.57 ± 0.61	2.6	0.09	0.00	0.0
SC51T	390S109	0.00	1.89 ± 0.66	1.9	0.11	0.00	0.0
S52	390S046	5.41 ± 0.26	10.81 ± 2.07	146.1	1.85 ± 0.42	2.12 ± 0.39	7.22
S53	390S047	3.12 ± 0.26	5.18 ± 2.28	83.2	2.01 ± 0.54	1.60 ± 0.42	8.56
S54	390S048	2.85 ± 0.16	1.68 ± 1.14	72.9	1.40 ± 0.29	1.16 ± 0.31	20.85
S55	390S049	0.00	0.67 ± 0.83	0.7	0.30	0.00	0.0
S56	390S050	1.11 ± 0.10	1.73 ± 0.97	29.6	0.63 ± 0.18	0.42 ± 0.25	9.09
S57	390S051	0.85 ± 0.08	1.01 ± 0.93	22.3	0.55 ± 0.22	0.40 ± 0.17	11.55
S58	390S052	0.43 ± 0.06	1.38 ± 0.77	12.1	0.25 ± 0.14	0.46 ± 0.17	4.62
S59	390S053	0.48 ± 0.06	1.42 ± 1.01	13.3	0.24 ± 0.19	0.26 ± 0.15	4.97
S60	390S054	0.26 ± 0.06	0.71 ± 0.67	7.2	0.16	0.00	5.37
S61	390S055	0.41 ± 0.07	1.19 ± 0.97	11.5	0.23 ± 0.15	0.30 ± 0.10	5.11
S62	390S056	0.37 ± 0.07	0.92 ± 0.75	10.1	0.28	0.00	5.89
S63	390S057	0.67 ± 0.08	1.43 ± 1.06	18.3	0.43 ± 0.18	0.41 ± 0.18	6.81
SC63	390S110	0.50 ± 0.07	1.72 ± 0.93	14.2	0.23 ± 0.16	0.20 ± 0.12	4.31
S64	390S058	0.00	0.69 ± 0.77	0.7	0.20	0.00	0.0
S65	390S059	0.28 ± 0.03	0.70 ± 0.46	7.6	0.18 ± 0.07	0.11 ± 0.07	5.77
S66	390S060	0.42 ± 0.04	0.81 ± 0.50	11.3	0.24 ± 0.09	0.20 ± 0.07	7.48
S67	390S061	0.42 ± 0.06	1.18 ± 0.83	11.6	0.17	0.00	5.21
S68	390S062	1.29 ± 0.12	1.44 ± 1.14	33.6	0.69 ± 0.24	0.56 ± 0.19	12.21
S69	390S063	0.44 ± 0.08	1.70 ± 1.00	12.7	0.28	0.00	3.88
S70	390S064	6.56 ± 0.26	9.94 ± 2.05	173.8	4.50 ± 0.52	4.20 ± 0.64	9.30
S71	390S065	0.14 ± 0.03	0.79 ± 0.40	4.4	0.11	0.00	2.73
SC71	390S111	0.00	1.20 ± 0.56	1.2	0.07	0.00	0.0
S72	390S066	0.45 ± 0.04	1.00 ± 0.53	12.3	0.37 ± 0.09	0.28 ± 0.10	6.55
S73	390S067	0.26 ± 0.04	0.78 ± 0.42	7.3	0.18 ± 0.08	0.14 ± 0.06	4.99
S74	390S068	0.57 ± 0.08	0.65 ± 0.82	15.0	0.30	0.00	12.10
S75	390S121	40.07 ± 0.55	7.36 ± 2.59	1009.1	1.71 ± 0.36	1.56 ± 0.35	45.69

TABLE 7 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL Id[d, e]	ORISE Sample ID	Radionuclide Concentration (pCi/g)					% U-235 Enrichment
		U-235	U-238	Total U[a]	Co-60[b] (1173 keV)	Co-60[b] (1332 keV)	
S76	390S069	1.03 ± 0.11	1.95 ± 1.25	27.6	0.77 ± 0.26	0.75 ± 0.23	7.56
S77	390S070	0.25 ± 0.08	2.15 ± 1.23	8.4	0.29	0.00	1.76
S78	390S071	0.22 ± 0.06	1.48 ± 0.88	7.0	0.19	0.00	2.26
S79	390S072	0.00	1.26	0.0	0.31	0.00	0.0
S80	390S073	0.23 ± 0.05	1.40 ± 0.69	7.1	0.15 ± 0.15	0.20 ± 0.13	2.49
S81	390S074	0.21 ± 0.07	0.67 ± 1.03	5.8	0.36 ± 0.13	0.31 ± 0.17	4.57
SC81	390S112	0.19 ± 0.05	1.33 ± 0.97	6.0	0.16	0.00	2.14
S82	390S075	0.76 ± 0.09	1.64 ± 0.76	20.6	0.39 ± 0.19	0.25 ± 0.14	6.71
S83	390S076	0.00	0.65 ± 0.85	0.7	0.19	0.00	0.0
SC83	390S113	0.36 ± 0.05	1.22 ± 0.62	10.3	0.24 ± 0.11	0.15 ± 0.09	4.40
S84	390S077	0.12 ± 0.03	0.58 ± 0.37	3.6	0.08	0.00	3.13
S85	390S078	1.78 ± 0.10	1.86 ± 0.77	46.3	0.74 ± 0.19	0.66 ± 0.17	12.97
S86	390S079	0.00	0.32 ± 0.94	0.3	0.24	0.00	0.0
S87	390S080	0.00	0.70 ± 0.51	0.7	0.11	0.00	0.0
S88	390S081	0.20 ± 0.04	1.30 ± 0.70	6.3	0.10	0.00	2.35
S89	390S082	0.23 ± 0.06	1.44 ± 0.97	7.2	0.21 ± 0.11	0.12 ± 0.12	2.41
S90	390S083	0.21 ± 0.04	0.88 ± 0.84	6.2	0.23 ± 0.12	0.11 ± 0.13	3.62
S91	390S084	0.32 ± 0.03	0.80 ± 0.44	8.9	0.15 ± 0.09	0.15 ± 0.06	5.88
S92	390S085	0.46 ± 0.05	0.64 ± 0.58	12.0	0.14	0.00	9.94
S93	390S086	0.25 ± 0.05	1.52 ± 0.84	7.8	0.18 ± 0.12	0.10 ± 0.10	2.52
SC93	390S114	0.31 ± 0.04	1.08 ± 0.62	8.8	0.10	0.00	4.27
S94	390S087	0.00	1.14 ± 0.91	1.1	0.21	0.00	0.0
S95	390S088	0.00	0.70 ± 0.96	0.7	0.22	0.00	0.0
S96	390S089	0.13 ± 0.05	1.23 ± 0.64	4.4	0.14	0.00	1.58
S97	390S090	0.00	0.78 ± 0.85	0.8	0.21	0.00	0.0
S98	390S091	0.24 ± 0.05	1.47 ± 0.86	7.6	0.20 ± 0.12	0.17 ± 0.10	2.51
SC98	390S115	0.23 ± 0.05	1.56 ± 0.91	7.4	0.13	0.00	2.26
S99	390S092	0.00	2.04 ± 1.57	2.0	0.28	0.00	0.0

TABLE 7 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL Id[d, e]	ORISE Sample ID	Radionuclide Concentration (pCi/g)					% U-235 Enrichment
		U-235	U-238	Total U[a]	Co-60[b] (1173 keV)	Co-60[b] (1332 keV)	
S100	390S093	0.00	1.47 ± 0.69	1.5	0.15	0.00	0.0
S101	390S094	0.00	1.11 ± 0.75	1.1	0.10	0.00	0.0
S102	390S095	0.00	0.52 ± 0.74	0.5	0.13	0.00	0.0
S103	390S096	0.56 ± 0.10	1.72 ± 1.17	15.6	0.34 ± 0.21	0.28 ± 0.18	4.79
S104	390S097	0.00	1.46 ± 1.14	1.5	0.19	0.00	0.0
S105	390S098	4.34 ± 0.30	6.75 ± 2.46	115.2	3.05 ± 0.69	2.81 ± 0.65	9.09
S106	390S099	2.10 ± 0.14	3.22 ± 1.20	55.6	2.08 ± 0.34	1.77 ± 0.31	9.20
S107	390S100	0.15 ± 0.06	0.28 ± 0.77	4.0	0.22	0.00	7.73
S108	390S101	1.48 ± 0.13	1.96 ± 1.21	38.9	0.88 ± 0.27	0.85 ± 0.23	10.50

[a]Total uranium calculated by multiplying U-235 concentration by 25 (to account for U-234 concentration) and adding U-238 concentration.
[b]All samples were decay-corrected to sample collection date (9/91).
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Refer to Figures 17 through 19.
[e]Samples consisted of the top two inches of sediment. Some deeper samples were collected and are labeled SC. The deeper samples were either six or twelve inches deep. The twelve inch deep samples were split into a top sample and a bottom sample.

TABLE 8

ISOTOPIC URANIUM CONCENTRATIONS IN SITE BROOK SEDIMENT SAMPLES (KAPL)
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

KAPL ID[c,d]	Sample ID	Uranium Concentration (pCi/g)				% U-235 Enrichment
		U-238	U-235	U-234	Total U[a]	
S11	390S009	4.53 ± 0.45[b]	0.26 ± 0.10	5.41 ± 0.51	10.21 ± 0.69	0.89
S17	390S014	4.00 ± 0.41	0.67 ± 0.15	15.4 ± 1.2	20.0 ± 1.3	2.54
S19	390S016	11.1 ± 1.1	3.58 ± 0.54	92.3 ± 6.7	106.9 ± 6.8	4.80
S21	390S018	5.30 ± 0.53	0.55 ± 0.15	12.9 ± 1.1	18.8 ± 1.2	1.59
S29	390S024	4.49 ± 0.65	4.11 ± 0.67	93.6 ± 7.4	102.2 ± 7.4	12.46
S30	390S025	5.51 ± 0.69	3.13 ± 0.53	84.0 ± 6.2	92.6 ± 6.2	8.12
S31	390S026	0.26 ± 0.09	0.11 ± 0.07	3.31 ± 0.41	3.68 ± 0.42	6.17
S34	390S028	3.83 ± 0.54	6.97 ± 0.85	204 ± 14	215 ± 14	22.02
S37	390S031	2.50 ± 0.30	1.65 ± 0.25	47.7 ± 3.3	51.8 ± 3.3	9.30
S40	390S034	0.69 ± 0.13	0.08 ± 0.05	3.11 ± 0.34	3.88 ± 0.37	1.77
S41	390S035	3.64 ± 0.52	3.05 ± 0.51	79.2 ± 6.2	85.9 ± 6.2	11.52
S50	390S044	1.83 ± 0.23	0.20 ± 0.07	3.11 ± 0.32	5.14 ± 0.40	1.67
S54	390S048	1.54 ± 0.31	2.27 ± 0.42	66.8 ± 5.0	70.6 ± 5.1	18.62
S70	390S064	6.9 ± 1.6	4.9 ± 1.3	132 ± 18	143 ± 18	9.84
S88	390S081	1.01 ± 0.16	0.18 ± 0.07	2.99 ± 0.32	4.17 ± 0.37	2.70
S105	390S098	4.27 ± 0.55	3.04 ± 0.49	86.6 ± 5.9	93.9 ± 6.0	9.96
S106	390S099	2.64 ± 0.45	1.83 ± 0.40	39.4 ± 3.1	43.8 ± 3.2	9.73
S107	390S100	0.35 ± 0.09	0.10 ± 0.06	1.93 ± 0.24	2.38 ± 0.26	4.26
SC42B	390S106	0.53 ± 0.12	0.07 ± 0.05	0.91 ± 0.16	1.51 ± 0.21	2.01
SC6	390S116	3.16 ± 0.36	0.19 ± 0.08	4.23 ± 0.45	7.58 ± 0.58	0.93
S28	390S119	1.56 ± 0.76	9.4 ± 2.2	234 ± 25	245 ± 25	48.16
S75	390S121	11.1 ± 3.0	35.6 ± 6.5	1040 ± 110	1080 ± 110	33.19

[a]Total uranium concentrations based on sum of U-234, U-235, and U-238 concentrations.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.
[c]Refer to Figures 17 through 19.
[d]Samples consisted of the top two inches of sediment. Some deeper samples were collected and are labeled SC. The deeper samples were either six or twelve inches deep. The twelve inch deep samples were split into a top sample and a bottom sample.

TABLE 9

SAMPLES COLLECTED BY ARGONNE NATIONAL LABORATORY AT THE COMBUSTION ENGINEERING SITE[a] WINDSOR, CONNECTICUT

Sample Number[b]	Matrix	Uranium Concentration (pCi/g)			% U-235 Enrichment
		U-238	U-235	U-234	
1	Soil	0.375 ± 0.024	Natural[c]	0.375 ± 0.024	Natural
2	Soil	0.506 ± 0.018	Natural	0.506 ± 0.018	Natural
3	Soil	0.435 ± 0.044	1.670 ± 0.170	59.2 ± 6.0	37 ± 7
4	Soil	3.67 ± 0.39	20.0 ± 1.0	774 ± 0	46 ± 6
5	Water (Suspended solids)	1.56 ± 0.06	0.017 ± 0.003	2.70 ± 0.10	0.2 ± 0.1
6	Sediment	0.657 ± 0.069	0.159 ± 0.021	5.85 ± 0.61	3.6 ± 0.9
7	Water	0.110 ± 0.009[d]	0.005 ± 0.001[d]	0.160 ± 0.008[d]	0.7 ± 0.1
8	Sediment	2.01 ± 0.20	0.774 ± 0.077	30.1 ± 3.0	6 ± 1
9	Sediment	3.97 ± 0.15	1.96 ± 0.11	63.3 ± 0.6	7.1 ± 0.6
10	Sediment	0.395 ± 0.032	0.154 ± 0.020	6.03 ± 0.13	5.7 ± 1
11	Water	0.130 ± 0.011[d]	0.022 ± 0.004[d]	0.752 ± 0.022[d]	2.5 ± 0.8
12	Soil	0.325 ± 0.030	0.054 ± 0.012	2.24 ± 0.08	2.4 ± 0.7
13	Soil	0.395 ± 0.040	0.17 ± 0.03	6.10 ± 0.34	6 ± 2
14	Organic Soil	11.0 ± 0.6	147 ± 2	5490 ± 10	68 ± 4
15	Soil	0.543 ± 0.048	2.13 ± 0.10	73.5 ± 0.6	38 ± 4
16	Water and Sludge	0.886 ± 0.069	0.249 ± 0.036	9.19 ± 0.40	4 ± 1

[a]From ANL May 1996 Report—Estimation of Uranium and Co-60 Distribution Coefficients and Uranium-235 Enrichment at the Combustion Engineering Company Site in Windsor, Connecticut.
[b]Refer to Figures 20 and 21.
[c]Natural uranium has 0.007 U-235 by mass total uranium.
[d]Units are in pCi/L.

REFERENCES

Argonne National Laboratory (ANL1996). Estimation of Uranium and Co-60 Distribution Coefficients and Uranium-235 Enrichment at the Combustion Engineering Company Site in Windsor, Connecticut. Argonne, IL; May 1996.

Oak Ridge Institute for Science and Education (ORISE). Designation Survey Plan for the Combustion Engineering Site, Windsor, Connecticut. Oak Ridge, TN; November 12, 1993.

Oak Ridge Institute for Science and Education (ORISE). Designation Survey Combustion Engineering Site, Windsor, Connecticut. Oak Ridge, TN; April 1994.

U.S. Department of Energy (USDOE). Radiation Protection of the Public and the Environment. DOE Order 5400.5. Washington, D.C.; February 8, 1990.

U.S. Department of Energy, memorandum from A. Williams to file, "Tentative Authority Determination - Combustion Engineering Site, Windsor, Connecticut," June 22, 1993.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or their employers.

LABORATORY ANALYTICAL INSTRUMENTATION

Alpha Spectrometry System
Tennelec Electronics Model
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Surface Barrier and Ion Implanted Detectors
(Canberra, Meriden, CT and
Tennelec, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

Low Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

APPENDIX B

ANALYTICAL PROCEDURES

APPENDIX B

ANALYTICAL PROCEDURES

GAMMA SPECTROMETRY

Samples of solid materials (soil, sediment, debris, residues, and construction material) were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Co-60	1.173 MeV and 1.332 MeV
U-235	0.143 MeV or 0.186 MeV
U-238	0.063 MeV or 0.093 MeV from Th-234*

*Secular equilibrium assumed.
Spectra were also reviewed for other identifiable photopeaks.

ALPHA SPECTROMETRY

Soil, sediment and miscellaneous samples were crushed, homogenized and analyzed for isotopic uranium. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. Barium sulfate precipitate was redissolved and the specific elements of interest were individually separated by liquid-liquid extraction and re-precipitated with a cerium fluoride carrier. The precipitate was then counted using surface barrier and ion implanted detectors (Oxford and Canberra), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Canberra).

NICKEL-63 ANALYSES

Nickel was separated from the interfering transition elements by an anion exchange column technique and then was eluted with 8M HCl while zinc, cobalt, manganese and iron remain absorbed. Further purification was achieved using the highly specific dimethyl glyoxime (DMG) precipitation in a slightly

alkaline media followed by extraction in chloroform. The nickel was then back extracted in 1M HCl and the chemical recovery was quantitated using spiked duplicates. Ni-63 activity was then determined using a liquid scintillation counter.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

When the activity was determined to be less than the MDC of the measurement procedure, the result was reported as less than MDC. Because of variations in background levels, measurement efficiencies, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, Revision 7.1 (September 1993)
- Laboratory Procedures Manual, Revisions 8 and 9 (September 1993 and January 1995)
- Quality Assurance Manual, Revision 6 (July 1993)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry recognized organization were used.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.